AERONAUTICAL ENGINEERING REVIEW

INSTITUTE OF THE AERONAUTICAL SCIENCES

NOVEMBER 1948

NEW! *High Strength* NUT DESIGN CUTS SIZE AND WEIGHT OF AIRFRAME COMPONENTS

—*with the famous Self-Locking Red Elastic Collar that protects permanently against* IMPACT! VIBRATION!

The NEW ESNA High Strength-Double Hex Nuts have been scientifically engineered to accomplish distribution of thread load with minimum weight and wrench diameter. They develop 185,000 psi. min. in NAS high strength aircraft bolts, and are completely interchangeable with existing internal wrenching nuts; yet their double hex design permits a weight reduction of 66%, and a height reduction of 50%. The engine mount fittings of the DC-6 shown above clearly illustrate how fitting size can be reduced. Similar design advantages can be gained for such problems as edge distance, nut spacing and flange width. Of great importance maintenance-wise is the fact that no special wrenches are required—any socket wrench will do.

Further—like all Elastic Stop Nuts—the NEW High Strength Nut remains self-locking in both fully seated and positioned settings.

HERE'S A CHALLENGE: Send us complete details of your toughest bolted trouble spot. We'll supply test nuts—FREE, in experimental quantities. Or, if you want further information, write for literature. Elastic Stop Nut Corporation of America, Union, New Jersey. Representatives and Agents are located in many principal cities.

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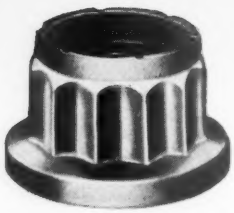


THE RED ELASTIC COLLAR IS VISIBLE EVIDENCE OF LOCKING SECURITY

Threadless and permanently elastic, it provides these 4 outstanding features:

1. **Protects against nuts loosening due to VIBRATION**
2. **Keeps locking threads CORROSION FREE**
3. **Provides for accurate BOLT LOADING**
4. **Seals against LIQUID LEAKAGE along the bolt threads.**

AND IT IS RE-USABLE

ELASTIC STOP NUTS

INTERNAL WRENCHING

ANCHOR

WING

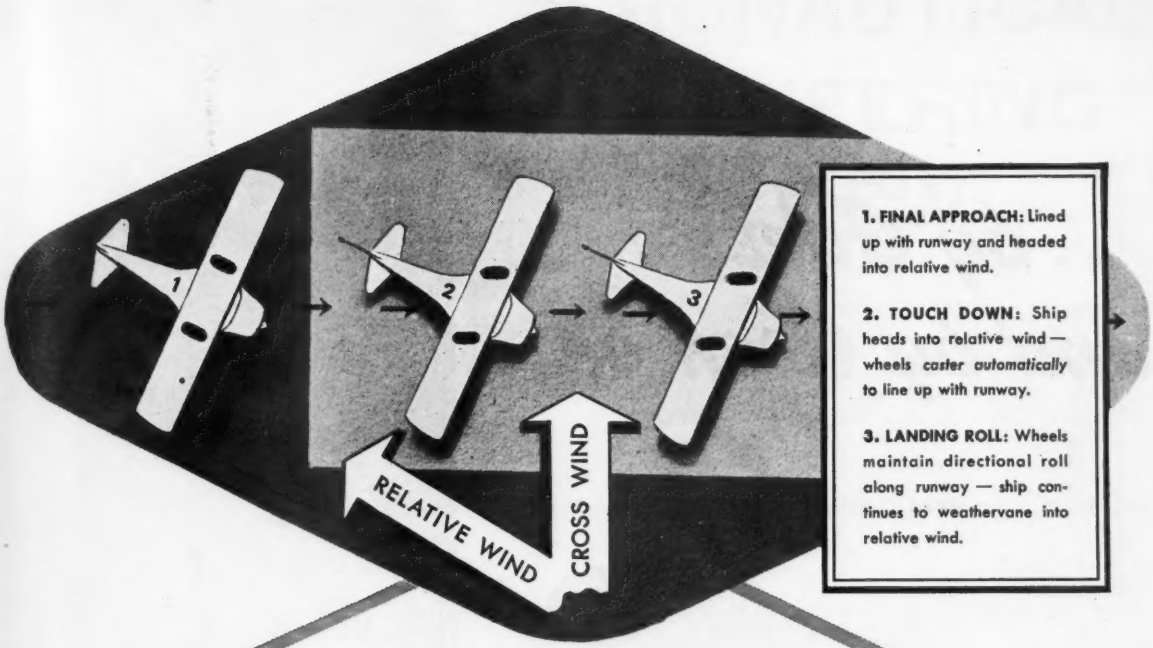
SPLINE

CLINCH

GANG CHANNEL

CAP

PRODUCTS OF: ELASTIC STOP NUT CORPORATION OF AMERICA



1. FINAL APPROACH: Lined up with runway and headed into relative wind.

2. TOUCH DOWN: Ship heads into relative wind — wheels *caster automatically* to line up with runway.

3. LANDING ROLL: Wheels maintain directional roll along runway — ship continues to weathervane into relative wind.

Now you can land cross-wind!

Pilots are hailing the new Goodyear Cross-Wind Landing Wheel as revolutionary. Developed for the C.A.A. by Goodyear, it offers these major advantages: the first practical use of single-strip airports—more flying hours in higher wind conditions — increased revenue for flight operators—flight training accomplished in less time and trouble and with less damage to wing tips and props. Already the Goodyear Cross-Wind Landing Wheel is available for Cessna, Stinson and other makes of ships. Investigate the advantages of using this gear on your plane. For complete details, write: Goodyear, Aviation Products Division, Akron 16, Ohio or Los Angeles 54, California.

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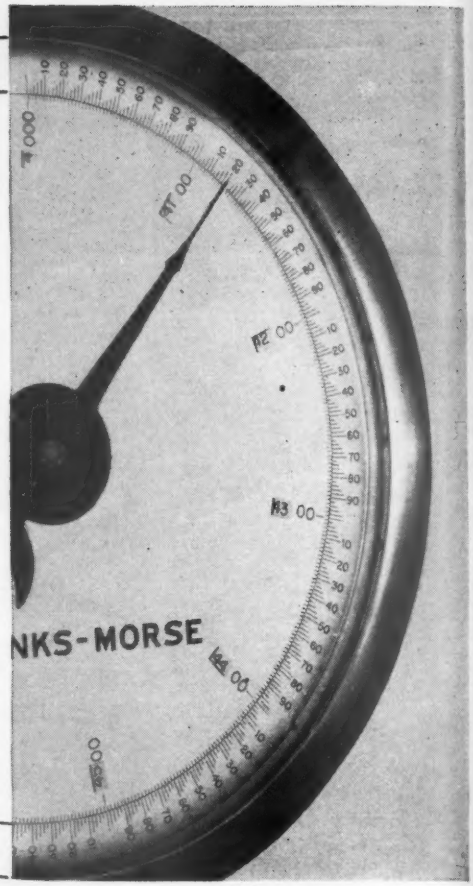
..by Guess and by Gosh or..



Naturally in the aircraft industry, there's no place for "by guess and by gosh"... no guesswork on weights... from the smallest part right up to wheel loadings on finished planes.

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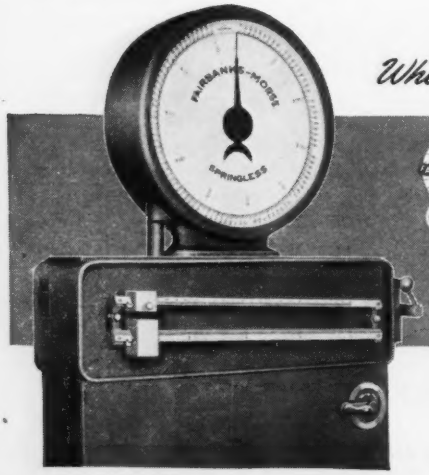

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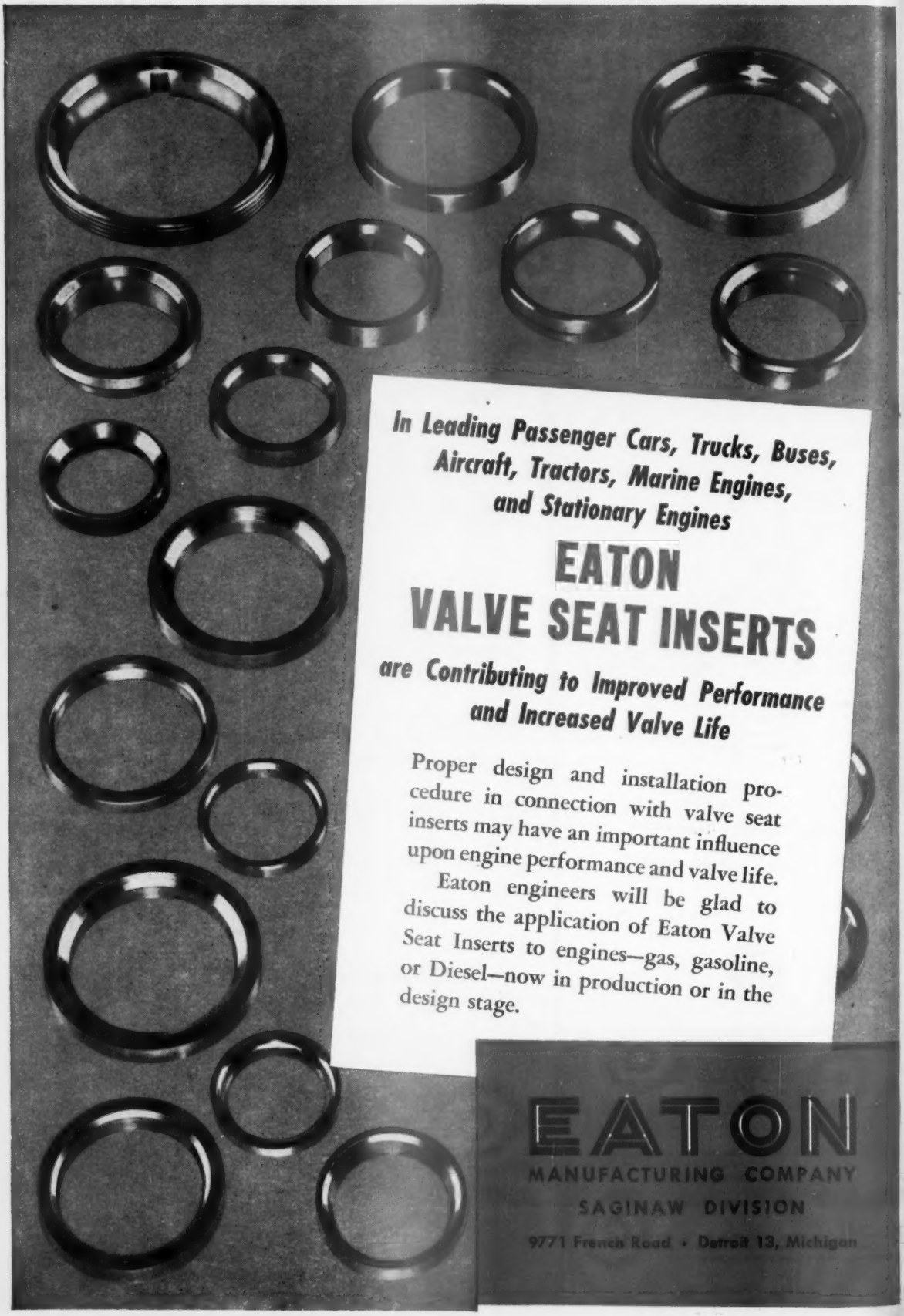
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I.A.S. News

A Record of People and Events of Interest to Institute Members

NACA Research Expert Chosen for Wright Brothers Lecture

Abe Silverstein to Speak on Aircraft Propulsion Research in 12th Annual Wright Brothers Lecture in Washington December 17; Clark Millikan to Act as Chairman.

AN OUTSTANDING RESEARCH SCIENTIST and 1946–1947 Chairman of the I.A.S. Cleveland Section has been selected the 1948 Wright Brothers Lecturer in the person of Abe Silverstein, Chief of the Wind Tunnel and Flight Division, National Advisory Committee for Aeronautics, Flight Propulsion Research Laboratory.

Chairman of the Lecture will be Dr. Clark B. Millikan, Acting Director, Guggenheim Aeronautical Laboratory, California Institute of Technology.

Selection of Abe Silverstein is in line with I.A.S. policy to have as the Wright Brothers Lecturer a prominent aeronautical scientist alternately from the United States and abroad. The last Lecture was delivered by Dr. Sydney Goldstein, of Great Britain, who spoke on suction airfoils.

▸ **Propulsion Research**—Mr. Silverstein has chosen the subject, "Research on Aircraft Propulsion Systems," for his Lecture in the U.S. Chamber of Commerce Building Auditorium, Washington, D.C., next December 17.

His paper will be divided into three sections: Section 1 to deal with the evaluation of research problems; Section 2 to be devoted to general research techniques and equipment; and Section 3 on the present status of the problem.

As Chief of the Wind Tunnel and Flight Research Division of N.A.C.A., Abe Silverstein has directed the design and operation of a series of large continuous-flow supersonic wind tunnels for the study of engine inlets and aerodynamic problems relating to aircraft propulsion at supersonic speeds. He also instigated improvements in the design and instrumentation of supersonic tunnels leading to the successful design of the N.A.C.A. 8 by 6 ft. Supersonic Wind Tunnel, world's largest, now nearing completion at Cleveland, for extending current research on large models of aircraft propulsion systems up to air velocities twice the speed of sound.

In 1945 he presented a paper at a gas-turbine conference on investigations of jet propulsion engines in the N.A.C.A. Altitude Wind Tunnel, and in 1947 delivered a lecture before the Air Command and Staff School of the U.S.A.F. Air University on ram-jet propulsion.

▸ **At Joint Meeting in London**—Abe Silverstein was one of the American representatives who attended the joint meeting of the Royal Aeronautical Society and Institute of the Aeronautical Sciences in London in September, 1947. He gave a paper reviewing the status of aircraft ice protection.

He also has had published numerous N.A.C.A. reports on high altitude cooling and internal aerodynamics of ram-jets and has served on N.A.C.A. Committees concerned with aerodynamics, guided missiles, and internal flow.

1948 Wright Brothers Lecturer: *Abe Silverstein, Chief of the Wind Tunnel and Flight Research Division, N.A.C.A. Cleveland Laboratory, will deliver this year's annual Wright Brothers Lecture, December 17, in Washington, D.C.*

A Fellow of the Institute, Mr. Silverstein is a member of the Committee on Arrangements for the joint meeting of the I.A.S. and Royal Aeronautical Society to be held in New York City, May, 1949.

The Wright Brothers Lecture is made possible by The Vernon Lynch Fund and commemorates the first flight of the Wright Brothers at Kitty-hawk in 1903.

National Meetings Calendar

December 17	Wright Brothers Lecture, Washington, D.C.
January 24–27	Seventeenth Annual Meeting, New York

For details see page 37.

New I.A.S. Publications

Symposium on Sandwich Construction; Stevens Institute Reports to Navy; First Annual Edition of the Aeronautical Engineering Index; and Other Important Technical Papers Now Available.

THROUGH THE EXPANDED ACTIVITIES and facilities of the Institute's Publication and Preprint departments, more and more specialized technical papers and reports are continuously becoming available to the aircraft industry. These include not only papers presented at I.A.S. meetings, or to the Institute's magazines, but also special reports that originate in laboratories where further publication or wide distribution of the information is impractical.

The Institute has found through experience that valuable technical information is ofttimes sidetracked for lack of ways and means to have it circulated. Papers and reports of unusual length, having a highly limited reader-audience, do not usually appeal to commercial publishers. Unless the individual author, laboratory, or company has other printing and distribution facilities readily available, the paper dies aborning. Yet, the data contained in it may hold the solution to the problems confronting a small but important group of scientists or engineers elsewhere.

It is this gap that the Institute hopes eventually to bridge through its Fairchild Publication Fund and printing facilities. College, university, and independent aeronautical laboratories are being invited to submit special papers and reports to us. Such papers, upon approval of the editorial committees, will be printed in sufficient quantities to cover the probable demand and will be made available to I.A.S. members at cost.

New papers will be announced monthly on the Preprint Pages of this magazine (pages 38–39 of this issue). The following special papers are immediately available.

Experimental Towing Tank Reports

Stevens Institute of Technology is preparing a series of hydrodynamic reports for the Navy, based on tests made in the Experimental Towing Tank. With the Navy's sanction, these important reports are being made available to the industry in preprint form through the I.A.S. Fairchild Publication Fund.

Of the six reports in preparation at Stevens, three have been completed and are ready for distribution. These are:

"An Analysis of the Fluid Flow in the Spray Root and Wake Regions of Flat Planing Surfaces."

"On the Pressure Distribution for a Wedge Penetrating a Fluid Surface."

"Wave Contours in the Wake 20° Deadrise Planing Surface."

Symposium on Sandwich Construction

This 100-page booklet contains the complete papers of eight outstanding American authorities and the discussions of other experts in the field of sandwich construction. Covering everything from research to the application of sandwich construction in aircraft, this symposium is a valuable contribution to the aeronautical sciences and a *must* for structural engineers.

The symposium was under the chairmenship of: Part I, Martin Goland, Engineering Mechanics Division, Midwest Research Institute; Part II, H. B. Gibbons, Chief of Structures, Chance Vought Aircraft Division, United Aircraft Corporation. The panel discussers include: C. B. Norris, Timber Mechanics Division, Forest Products Laboratory, U.S. Department of Agriculture; N. J. Hoff, Professor of Aeronautical Engineering, Polytechnic Institute of Brooklyn; E. Reissner, Associate Professor of Mathematics, Massachusetts Institute of Technology; C. Libove, National Advisory Committee for Aeronautics; E. MacDonough, Chief, Structures Design Group, Chance Vought Aircraft Division, United Aircraft Corporation; H. C. Engel, Supervisor of Laboratory—Non-Metals, The Glenn L. Martin Company; J. Weber, Structural Engineer, The Glenn L. Martin Company; and R. Schwartz, Materials Laboratory, Air Materiel Command, Wright Field.

Theory of Free Molecule Flow

"Applications of the Theory of Free Molecule Flow to Aeronautics," by Holt Ashley, Instructor in Aeronautical Engineering at Massachusetts Institute of Technology. The breakdown of certain assumptions of conventional aerodynamics in the case of highly rarified gas is shown to call for the use of the theory of free molecule flow in studying forces on bodies moving above 120–150 km. in the earth's atmosphere. In his article, the author develops techniques for finding the lift and drag coefficients of any objects and makes an analysis of the possibility of aerodynamically sustained flight at free molecule altitudes.

The Institute's editorial committee felt that the contributions made in this paper justified its publication as a special 88-page booklet.

Other Recently Published Preprints

In addition to the foregoing special publications, preprints from the Annual Summer Meeting have been completed and distributed to those members placing advance orders. Unfortunately, several of the papers announced before the meeting as being available in preprint form had to be omitted and others limited in the quantity reproduced.

Copies of the majority of these preprints are currently available, however, and may be obtained upon orders as long as the supply lasts. (See Preprint Pages 38–39 for further information.)

Aeronautical Engineering Index

The first annual edition of the INDEX is meeting with a gratifying response from the industry and libraries. The amount of work that went into the compilation and indexing of all important aeronautical articles and books reviewed and abstracted in 1947 appears to have been justified.

Volumes of the current edition are limited, and it is suggested that members desiring copies place their orders immediately.

It is planned to have the next volume, covering the year 1948, ready for publication and distribution in February.

Elastic Stop Nut Becomes New I.A.S. Corporate Member

Elastic Stop Nut Corporation of America, Union, N.J., has joined the Institute of the Aeronautical Sciences, making a total of 183 I.A.S. Corporate Members.

▸**Design of Swedish Inventor**—In 1927 a young Swedish inventor named Carl Swanstrom came to the United States with a tentative design for a one-piece self-locking nut that would remain tight under the most severe conditions of load and vibration. Months of tests and research resulted in the nut with the integral "red elastic collar."

Under leadership of Swanstrom, the Elastic Stop Nut company grew from a small machine shop manufacturing a few tens of thousands of nuts a year to a corporation that during World War II produced more than 300,000,000 in a month.

Development of the all-metal plane and growing production made necessary a fastener that would permit simple, fast assembly methods yet provide certain protection from the vibration and strain imposed by the higher speeds and greater loads of each new aircraft design.

▸**New Designs Ready**—Every all-metal plane built in the U.S. has carried Elastic Stop Nuts somewhere in its structure, and more than 2,400 different sizes and types of self-locking nuts designed to meet the special problems of the aircraft industry have been produced by the company in its 20 years of association with the industry. Today, after more than 2 years of field tests with air-frame and engine makers, two new nut designs are ready for use in jet planes.

One is a series of lightweight, high-tensile nuts in fractional sizes through 1 in. which will develop 185,000 lbs. per sq.in. minimum in N.A.S. high strength aircraft bolts. The other is a line of high-temperature self-locking nuts designed to withstand 1,200°F. jet-engine temperatures.

Pulse-Jet 'Copter Completes Test Flights Successfully

The first known pulse-jet-powered helicopter was announced by The General Tire & Rubber Company as having successfully completed its test flights in California. The aircraft was designed and built by General Tire's recently acquired Marquardt Aircraft Company, Venice, Calif., since acquired by Aerojet Engineering Corporation.

▸**Carries Greater Pay Load**—Differing from conventional-type helicopters in that power is supplied by two pulse-jet engines, one mounted on each tip of the rotary wing, the Marquardt M-14 Whirlajet will carry twice the pay load of equivalent orthodox 'copters for relatively short distances, makers declare. This is made possible by elimination of a heavy internal combustion engine with its required transmission, clutch, and free wheeling assemblies, together with the complexities of fuel, oil, ignition, and cooling systems.

Whirlajet Flight: *Pilot Bill Davis takes up first known pulse-jet-powered helicopter made by Marquardt Aircraft Company, now a subsidiary of Aerojet Engineering Corporation. Two pulse-jet engines, one mounted on each rotor tip, are supplied with fuel and ignition through lines integral with rotor blade. The M-14 "Whirlajet" is said to be able to carry twice the load of equivalent conventional helicopters for relatively short distances because of elimination of heavy internal combustion engine and accessories. Inasmuch as the jet-propelled rotor transmits no torque to the fuselage, need for auxiliary tail rotor is eliminated.*

The pulse-jet engine is an explosion type having reedlike valves in the air inlet as opposed to the ram-jet or continuous burning engine. Fuel and ignition are supplied through lines integral with the rotor blade.

▸**Reduces Costs**—According to Marquardt engineers, elimination of expensive and complex equipment permits a much lower comparative initial cost and ensures greatly reduced operational and maintenance costs. They predict unlimited applications for the pulse-jet-powered helicopter for military and commercial uses. Commercially, it would be economically superior for short-haul operations of cargo or passengers, being adaptable to airport-to-city shuttle service.

The Whirlajet was first tested at Muroc Air Force Base with further ground, hovering, and flight tests at the Torrance (Calif.) Municipal Airport. The ship was found to be stable beyond expectations in hovering and forward flight, which are attributable to the mass of the jet engines at the extreme tips of the rotor blades, company says.

Details of the M-14 experimental model are: gross weight, 1,000 lbs.; rotor diameter, 29 ft.; engines, two; control system, dual; uniform and cyclic pitch control, conventional; directional control, controllable vertical surface hinged about a 45-in. inclined axis, actuated by rudder pedals.

Fuselage construction is of welded steel tubing with wood and steel rotors of N.A.C.A. 8-H laminar-flow airfoil sections.

Performance data is limited because of low altitudes and low speeds flown so far.

Goodyear Blimp To Be World's Largest

Construction of the world's largest nonrigid airship will begin soon following completion of the contract for the engineering design work on the N-1 for the U.S. Navy by Goodyear Aircraft Corporation of Akron.

To be used for long-range patrol operations over polar and ocean areas, the new ship will have a helium capacity of 825,000 cu.ft., nearly twice the size of Navy blimps used for anti-sub patrol during the war and about 100,000 cu.ft. greater than that of the Navy's M-1 Mighty Mike.

▸**Engines Internal**—One of the most radical innovations for airship construction is the mounting of the engines within the double-deck, 87-ft. long car beneath the gas envelope, the propellers mounted on special booms outside. Maintenance and repair of the two 800-hp. Wright Cyclone engines thus will be possible during flight.

Crew living quarters are to be on the lower deck, away from the engines and controls. A total of 14 will man the ship.

The airship will be 324 ft. long, have a maximum height of 92 ft. and have a maximum width of 71 ft.

▸ **Retractable Landing Gear**—The N-1 will have retractable tricycle landing gear, a radical change from normal design to make possible the carrying of secret new electronic submarine-detection equipment. The envelope is to be rayon fabric coated with neoprene synthetic rubber, possessing the best strength-to-weight ratio ever used in lighter-than-air craft.

Cruising speed will be above the 50 knots of World War II blimps.

To Complete Weather Stations by June, Warner Tells ICAO

Dr. Edward P. Warner, I.A.S. Honorary Fellow and President of the International Civil Aviation Organization, informed the Council that the ocean weather station network in the North Atlantic is expected to be completed by June, 1949.

▸ **13 Stations**—The 13 ocean stations will provide meteorological reporting services throughout the region and will serve as communications relay points and search and rescue bases for aircraft flying between North America and Europe.

At present nine of the stations are maintained by nations whose territories ring the North Atlantic. The U.S. Government recently notified ICAO that the remaining four U.S. stations will be put into operation during the period January to June 10 under the following schedule: Station D, January 9; Station F, February 26; Station H, May 5; and Station G, June 10, 1949. Station E was placed in operation on September 29 last.

Other stations already in operation include Stations A and C (U.S.); Station B (Canada and U.S.); Station I and J (U.K.); Station K (Belgium and Holland); Station L (France); Station M (Norway, Sweden, and U.K.). At least two ships are required for maintenance of each station.

▸ **Rescued Sky Queen**—An ICAO weather ship, the U.S. Coast Guard Cutter "Bibb," manning Station C, rescued 69 passengers and crew of the flying boat Bermuda Sky Queen when it ran out of fuel and crash-landed in stormy Atlantic waters a year ago while en route from Ireland to Newfoundland.

Lear, Inc., Elects Lear, Mock to New Posts

William P. Lear and Richard M. Mock, both Associate Fellows of the Institute, were named to new posts in Lear, Inc.: Lear was elected to the newly created position of Chairman of the Board, and "Dick" Mock, nominated by Mr. Lear, was voted President by the Board. The Board also confirmed Mr. Lear's position as Director of Research & Development, in addition to his duties as Chairman of the Board.

William P. Lear (Left) and Richard M. Mock.

▸ **President for 20 Years**—Election of Mock to Presidency gives formal freedom to Lear, who has been President since inception of company nearly 20 years ago, to devote his time and energies to technical development of aircraft radio, automatic flight control, and wire recorder products. Mock, who has been Executive Vice-President since June, 1947, has been carrying out the duties of President for some time.

Joining Lear in 1940, Mr. Mock has held the positions of Application Engineer, Chief Engineer, Sales Manager, and Manager of the Electro Mechanical Division before being named Executive Vice-President.

As President, he will continue to direct company operations. Office of Executive Vice-President has been eliminated.

▸ **New Products To Be Listed**—Lear, Inc., has been expanding its electromechanical business, making electric actuators, motors, gear boxes, and electronic controls for aircraft. Its aircraft radio line includes portable radios, transmitters, receivers, a new lightweight automatic direction finder, and new products in the very-high-frequency field are to be announced.

Fluid Dynamics Division, American Physical Society, Completes Organization

Established by the Council of the American Physical Society in June, 1947, the Fluid Dynamics Division has now been completely organized.

Under By-laws approved by the Council, members of the Executive Committee were elected: for one-year term—Jesse W. Beams, Howard W. Emmons, and Th. von Kármán; for two-year term—Hugh L. Dryden and Paul S. Epstein; for 3-year term—Raymond J. Seeger and John G. Kirkwood.

The Executive Committee, by ballot, elected Mr. Seeger as its Chairman, Dr. Dryden as Vice-Chairman, and Mr. Emmons as Secretary-Treasurer.

The work of the original Fluid Dynamics Committee, consisting of Dr. Dryden, H. W. Emmons, J. G. Kirkwood, Dr. Clark Millikan, R. J. Seeger, Dr. von Kármán, and J. von Neumann, which has functioned for several years, will be continued in the future by the new Division.

Fluid Dynamics Program Announced by Dr. B. K. Erdoss

Established jointly last year by the Graduate Division of the College of Engineering, New York University, and the Graduate School of Stevens Institute of Technology, the second-year program of courses entitled "Fluid Dynamics of Aircraft and Ships" has been announced by Dr. B. K. Erdoss, I.A.S. Member and curriculum director and professor of hydrodynamics at Stevens.

Objective of the program is to train engineers to apply basic sciences to both aeronautical and nautical engineering. The full academic program of 1 year leads to a Master's degree.

▸ **Example of Cooperation**—Describing the undertaking as a unique example of close cooperation between two such institutions for a specific purpose, Dr. Erdoss said: "This program is the first instance where two institutions in the metropolitan area have offered a joint course of instruction leading to a Master's degree."

During the course, graduate engineers will have the opportunity to become familiar with several of the branches of the two schools and with N.Y.U.'s Guggenheim Wind Tunnel and the Stevens Experimental Towing Tank. Dr. Erdoss said this is the first time that a Master of Science degree in fluid dynamics applies to aircraft as well as ships.

Successful completion of 15 courses is necessary for the degree. The ten required courses that form backbone of the curriculum are given by the faculties of both schools and experimental stations, and they include mathematics, theoretical and applied fluid mechanics, thermodynamics, and experimental methods. Five elective courses may be chosen from a large list and are given at both N.Y.U. and Stevens.

Airborne Instruments Head Awarded Certificate of Merit

Hector R. Skifter, President of Airborne Instruments Laboratory, Inc., Mineola, N.Y., and four other members of the staff were awarded the

Certificate of Merit by direction of the President in recognition of services performed during World War II and their achievements as members of the National Defense Research Committee.

Mr. Skifter, an I.A.S. Member, together with John F. Byrne, Vice-President, and F. Clark Cahill, John W. Dyer, and Eugene G. Fubini, supervising engineers, who received the awards, served during the war with the electronic research laboratories operated under Columbia University and Harvard University.

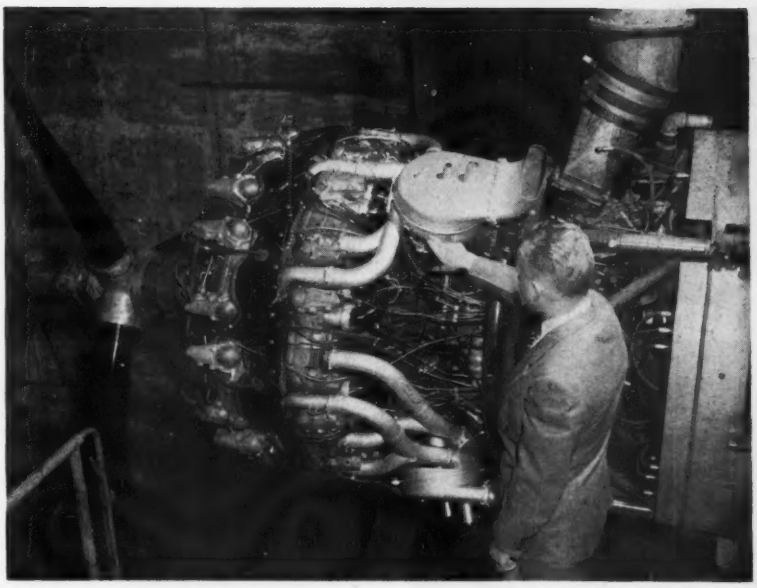
Airborne Instruments is a peacetime successor to the organization sponsored by Columbia during the war.

Gifts to the Institute Collections

John P. V. Heinmuller added rare photographs of early airplanes and pilots, assembled clippings and photographs on the Byrd Antarctic Expedition and other polar exploration and on early air mail, and other items to his previous generous gifts. A framed print of the Bell X-1 airplane in flight was received from Bell Aircraft Corporation through the courtesy of Lawrence D. Bell. Over 200 publications of the National Advisory Committee for Aeronautics were received from Republic Aviation Corporation, through the courtesy of Mrs. George Burrell. Mrs. Bella C. Landauer sent two French books: *Le Grand Cirque*, by Pierre Clostermann, Paris, 1948; and *Cinq Semaines en Aeroplane*, by Henry de Grosse, Paris, 1912.

Translations and reports were sent by Cornell Aeronautical Laboratory, through the courtesy of Elma T. Evans. Paul H. Wilkinson sent a copy of *Rund-Afrika-Flug*, by Friederich Andreas Fischer von Poturzyn.

Among the donors of additional gifts were the Airfreight Association, Inc.; Aluminum Company of America; Aluminum Development Association; Argentina Secretaria de Aeronautica; Australian Council for Scientific and Industrial Research; British Joint Service Mission; Brown University; Canadian Department of Transport; Colorado Division of Aeronautics; Saab Aircraft Company; Societé Météorologique de France; Society of Automotive Engineers; United Air Lines; United Nations; U.S. Air Coordinating Committee; Air Materiel Command; Civil Aeronautics Administration; National Advisory Committee for Aeronautics; National Bureau of Standards; National Military Establishment; Navy Department; Office of Technical Services; State Department; Treasury Department; and Congressional Committees on appropriations, expenditures in the executives departments, interstate and foreign commerce, interior and insular affairs, and the Senate and House Document Rooms.



WORLD'S MOST POWERFUL ENGINE OF ITS TYPE
First photo of the Wright turbo-cyclone 18 compound engine, developed by the Wright Aeronautical Corporation Division of the Curtiss-Wright Corporation. It is claimed that this engine will increase the range of U.S. military and commercial airplanes 20 per cent. Plans are under way to put the engine into production for the U.S. Navy on a $32,000,000 contract.

1949 Early Bird President: *Brig. Gen. Frank P. Lahm, first man to complete the Army training program as a pilot, is new President of Early Birds, succeeding George H. Scragg.*

Early Birds Elect Lahm New President

For the second time in succession a Cleveland man and I.A.S. Member has been chosen for the office of President of the Early Birds, pioneer pilots who flew before World War I. New President, succeeding George H. Scragg, is Brig. Gen. Frank P. Lahm (Ret.), a Member of the Institute of the Aeronautical Sciences and first man to complete the Army training program as a pilot.

Other I.A.S. members named to Early Bird posts were Capt. Ralph S. Barnaby, U.S.N., a Fellow, second Vice-President; and Glenn L. Martin, Honorary Fellow, 5-year Trustee.

I.A.S. Newslines

▶ Arcata Director . . . Associate Fellow, **Dr. Maurice A. Garbell** was named Technical Director of the Landing Aids Experiment Station at Arcata, Calif., by Transocean Air Lines late in September.

▶ Carrying out special assignments in addition to his duties as Contract Administrator for Bendix Aviation Corporation, **Edward R. Godfrey, Jr.,** an Associate Fellow, is now engaged in some guided missile activity in Bendix Research Laboratories.

▶ Heads Air University . . . **Gen. George C. Kenney,** Honorary Member, has been assigned as Head of the Air University, Maxwell Air Force Base, Montgomery, Ala. He had served as Commanding General, Strategic Air Command, since its organization in March, 1946.

▶ For Uniform C.A.A. Action . . . **Delos W. Rentzel,** Honorary Member and C.A.A. Administrator has sent a letter to all regional administrators

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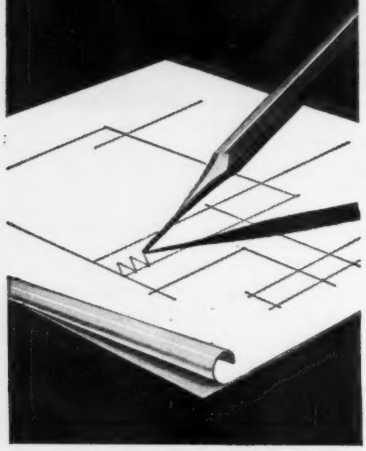

● Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

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ordering uniformity of action between various C.A.A. regions. Rentzel said responsibility for inspection and certification of scheduled air carriers is with the region in which headquarters of carrier is located, together with responsibility for coordinating operational matters affecting such carriers with other regions. Also, said Rentzel, "I believe it essential, in order to obtain the highest degree of uniformity in the application and interpretation of our standards, policies, practices, and procedures, that responsibility for resolving any questions which may arise regarding the application or interpretation of such matters be placed in one office . . . the Assistant Administrator for Aviation Safety."

▸ British Decoration . . . **Rear Adm. Lawrence B. Richardson,** I.A.S. Fellow and President of Fairchild Engine & Airplane Corporation, was made an honorary commander of the military division of the Most Excellent Order of the British Empire for services with the British forces during the war.

Corporate Member News

● Substantial new orders for a variety of specialized aircraft equipment for one commercial and two military types of planes have been received by **AiResearch Manufacturing Company,** Los Angeles. Orders include turbine refrigeration equipment for 30 Canadair DC-4M's and for 409 Republic F-84E's. In addition, a contract has been received from Boeing Airplane to equip B-50's with oil temperature regulating systems, exclusive of a previous, similar order for first B-50 aircraft.

● Turbojet engines now in production at **Allison Division** of General Motors have 64 per cent more take-off thrust per pound of engine weight than the original models placed in production at Allison in 1945. This performance improvement has taken place in the Model 400 (J-33) currently rated at 4,600-lb. take-off thrust. Use of water injection increases this rating nearly 20 per cent. At same time, specific fuel consumption has been decreased 15 per cent and operational life increased twelve times, with 300 hours between overhaul.

● Resumes Dividend . . . **Beech Aircraft Corporation** declared a dividend of $1.00 due last October 15 to stockholders on record October 1, marking first disbursement since 3 years ago when a like payment was made.

● Consolidated net income of **Bendix Aviation Corporation** for the 9 months ended last June rose to $7,019,489 from $4,644,992 earned in the corresponding period of last year.

● No Gifts, Please . . . With approaching Yuletide Season, **Boeing Airplane Company** takes occasion to remind all Boeing suppliers of company policy concerning gifts to its employees. Says Boeing: "Under this policy" (of purchasing on basis of greatest value to company unbiased by personal relationships) "gifts at any time to any of our employees are not only unnecessary but are embarrassing to the employee to whom the gift is offered."

● Chance Vought in Texas Show . . . A graphic display in the Aviation Show of the 1948 State Fair of Texas, held October 9–24, was featured by **Chance Vought Aircraft Division** of United Aircraft Corporation, now a "citizen" of the Lone Star State. Chance Vought's display showed the highlights in aircraft production during its existence, as well as some new developments now being carried out by the company. Included were models of the VE-7 World War I training plane built in 1917; an 02U-1, first Navy Corsair fighter; SB2U Vindicator; and an F6U-1 jet fighter soon to be produced in Texas.

● Stepping Up B-36 Production . . . With more than 30 B-36 heavy bombers completed to date, **Consolidated Vultee Aircraft Corporation** is speeding up production on the six-engined heavy at the Ft. Worth plant. Some 6,000–7,000 Convair workers have gone on 10-hour shifts per day, 6 days a week, on bomber construction. Schedules are expected to remain in effect for several months. The B-36B model features improved power plants and provisions for the XF-85 parasite fighter that tucks into the bomber's belly . . . Convair's XF-92 is being flight-tested at Muroc. Prototype has only Westinghouse jet engine, while operational model will also have rocket power with total of 13,000-lb. thrust. Top speed will be more than 800 m.p.h., but endurance for only ½-hour is reported. Wing is delta type.

● New Air-Cooled Power Plants . . . A new line of air-cooled, heavy-duty engines, ranging from 125 to 1,040 hp. and designed for maximum power and minimum space requirements, has been announced by **Continental Motors Corporation.**

● Two New Manuals . . . **The B. F. Goodrich Company** has brought out two new Manuals—one, a detailed installation and rework manual for C-54 De-icer systems; other, a 4-page description of new Highflex lightweight air hose for small pneumatic tools.

● For Future Expansion . . . Seventeen and one-half acres of vacant land at Oyster Bay near Hicksville, Long Island, have been purchased by **Grumman Aircraft Engineering Corporation** to provide for possible future expansion in that area.

● New Jack & Heintz President . . . Directors of **Jack & Heintz Precision Industries, Inc.,** elected Kenneth G. Donald as President. Byron C. Foy resigned as Chairman of the Board and President to permit him to devote more time to other interests, but will continue as a Director. Donald has been General Manager of the company for several months.

● Parasite fighter, XF-85, built by **McDonnell Aircraft Corporation,** completed its first powered flight at Muroc Air Force Base early in September. Performance was satisfactory, although difficulty was experienced in recapturing process by specially modified B-29.

• Forty-two North American AT-6 Texan trainers are being reconditioned at **North American Aviation, Inc.,** Downey plant for the Siamese Royal Air Force and Navy. In addition, North American has been reconditioning 30 AT-6's for the Argentine Navy . . . Construction of a $750,000 warehouse on 17-acre tract adjacent to the main plant in Los Angeles was begun September 15. Facility will be ready for occupancy March 1, 1949, and will add 160,000 sq.ft. of covered floor area to present total of 3,822,420 sq.ft. now operated at Los Angeles, Downey, and Long Beach.

• Bank Opens Branch at Idlewild . . . **The National City Bank of New York** opened a branch at N.Y. International Airport in the Administration Building in September.

• Global Tickets . . . An interline agreement that makes possible deluxe flight around the world over the combined networks of **Northwest Airlines, Inc.,** and Air France in less than 96 hours has been signed. Globe-girdling ticket will be $1,700 . . . Northwest has reduced number of corporate officers and realigned their responsibilities in a move to "simplify the company's management." Changes made: Position of Executive Vice-President was abolished, as was position of Eastern Region Vice-President; K. R. Ferguson, who has been Vice-President in Charge of Engineering & Planning, was elected Vice-President in Charge of Operations & Engineering; Donald J. King, who has been Vice-President in Charge of Orient Operation since inception of the service, will terminate his duties in that position by January 1, resign from the post, and return to flying status.

• New Quarters in Miami . . . **Pan American World Airways System** has moved its Miami district reservations office to new quarters at the Pan American base adjoining Miami International Airport. New offices, on fourth floor of center wing of main hangar, are equipped with "sell and report" reservations system.

• All propeller turbine and turbojet aircraft engines produced by **Pratt & Whitney Aircraft Division,** United Aircraft Corporation, will hereafter be called "Turbo-Wasps," company announced. While the name will be applied to all turbine-type engines made by P. & W., pure jet types and prop-jets will be identified by use of letters "J" or "P," respectively, a type number, and a letter designating the model. First engine, now in production,

NEW ALL-WEATHER FIGHTER TESTING AT MUROC

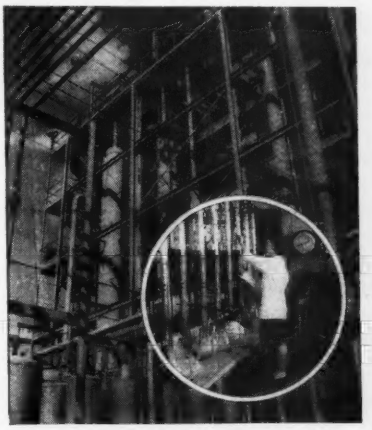
Small frontal area and razor-thin wing of Northrop XF-89, new all-weather fighter built for the Air Force and now testing at Muroc Air Force Base, is shown in head-on view (top) indicating high speed potentiality. Though performance remains undisclosed, it is expected to develop speeds high even by today's standards. Air intakes for two jet engines located forward of wing leading edge offer minimum drag, and small high pressure tires have the advantage of minimum weight and size for retraction in the thin airfoil. Nose-wheel strut is short, giving plane a scalded-cat appearance in take-off. Horizontal stabilizer is placed high (bottom) to avoid turbulence caused by high velocity airflow over wing and to clear hot exhaust gases. Crew of two, pilot and radar observer, man the fighter, which is capable of seeking out other aircraft and ground installations by day or night regardless of weather. Cockpit is pressurized and ejection seats are provided. Wing span is approximately 50 ft.; length, 50 ft.; and height overall, 15 ft. Design gross weight is more than 30,000 lbs.

Silicone News

DC

HUNDREDS OF AUTHORS

Thanks to the cooperative efforts of hundreds of scientists and engineers in almost every field of industry, we have been able to compile a comprehensive new booklet about DC 200 Fluids.



In early 1943 glass distillation columns supplied the demand for silicone products. By 1944, we had completed a multi-million dollar plant to supply war time requirements. During the past four years plant capacity has been tripled to supply the domestic and foreign markets.

We had been producing DC 200 Fluids for less than a year when we published a 4-page leaflet describing these remarkably stable silicone fluids. Our newest publication is a 32-page booklet describing some of the more typical applications and giving data on the more significant properties of the DC 200 Fluids.

This volume of information is evidence of a unique and useful combination of properties in the fluids themselves. It is proof of the ready acceptance given to these basically new materials by scientists, engineers and technicians in almost every industry. They have improved the performance of all sorts of devices by capitalizing on the properties of DC 200 Fluids. We, in turn, have gained knowledge and experience by giving technical assistance.

The benefits of our years of research and experience in producing DC 200 Fluids and in adapting them to many different applications are made available in booklet No. S-C-13. We hope that you will call on the technical representatives assigned to each of our branch offices for any additional information or assistance.

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VERSATILITY

is called "Turbo-Wasp J-6B," has announced rating of 5,000-lb. thrust, and powers Grumman F9F-2 Panther.

• One of the most powerful aviation fuels to be manufactured was first used to limited extent in Thompson Trophy Race planes last September. Designated by its makers, the **Shell Oil Company, Inc.**, as SMT-1 (for Shell Methyl Triptane-1), it is claimed to permit engines to develop nearly twice the power obtained with present commercially available fuels.

• Solar Buys Des Moines Plant . . . Purchase of the five-story building it now occupies at 18th & Grand Ave., Des Moines, for approximately $725,000 has been announced by **Solar Aircraft Company.** Solar has occupied building on a lease basis since May, 1942.

• Further centralization of operations along its 10,700-mile system has been taken by **United Air Lines, Inc.**, with the transfer to Denver of routing control of all four-engined equipment. Flight managers at the Stapleton Airfield operating base now have 24-hour supervision over all DC-6's and DC-4's. New setup has resulted in less delays and greater overall efficiency, United says. Not only is constant check kept on availability of four-engined planes at all stations on air-line's system, but progress of all flights is followed as well . . . C.A.A. has formally approved U.A.L.'s second officer training school in Cheyenne. Approximately 120 student pilot-engineers are currently in training.

The Lockheed P2V Patrol Bomber

The Lockheed P2V Navy Bomber is well known for its ability to fly farther than any other plane in the world today.

Not so well known is the effectiveness of the P2V for:

Multi-engine training
Strategic transport
Long-range reconnaissance
Sea search
Tactical photography
Aerial mine laying
Torpedo action

These are some of the many uses of the Lockheed P2V Patrol Bomber, the Navy's versatile holder of the world's long-distance nonstop flight record (11,236 miles).

LOOK TO LOCKHEED FOR LEADERSHIP

Lockheed Aircraft Corp.

Burbank, California

Meet Your Section Chairman

Jere T. Farrah

Seattle Section

Just 10 years after being elected Chairman of the Student Branch of the Institute at University of Michigan, Jere T. Farrah was named chairman of the I.A.S. Seattle Section.

▶ **Had Scholarship**—A Canadian, born in St. Thomas, Ontario, September 5, 1916, Mr. Farrah attended University of Michigan and was graduated in 1938 with the degrees of Mechanical and Aeronautical Engineering, holding the Sheehan Scholarship in his senior year.

Following graduation, he worked as a time-study engineer for the Alpena Garment Company of Alpena, Mich., for 2 years. In 1942 he became Junior Engineer for Norriss & Elliott, Inc., Columbus, Ohio, a firm of industrial engineers. He was promoted to Senior Engineer, and in June, 1942, joined American Airlines as Chief Flight Analyst in the Flight Test Section.

When American entered into the DC-6 contract with Douglas Aircraft in September, 1944, Jere Farrah held the job of DC-6 Coordinator, coordinating the requirements of the various engineering groups and other departments with respect to the completed aircraft.

Next, a year later, a relatively short period of time was spent in organizing an Industrial Engineering Group for American Manager of the Group. This work was cut short by his appointment as Manager of Aircraft Procurement in connection with American Overseas Airlines' contract for Boeing Stratocruisers, and he has been based in Seattle since May, 1946.

▶ **Taught at N.Y.U.**—During the Winter Term, 1946, Mr. Farrah was Adjunct Professor at New York University, teaching flight research methods in a night course.

In addition, he wrote a series of articles in *Aviation* magazine with R. D. Speas and S. H. Hinton on "Cruise Control" in 1943. Also, the JOURNAL OF THE AERONAUTICAL SCIENCES carried an article on "Problems of Routine Propeller Balancing," which he wrote for the June, 1943, issue.

For relaxation, Mr. Farrah is an amateur photographer, reads a great deal, and includes such practical pursuits as keeping both his car and house in "an acceptable state of repair."

Harold T. Johnson

Texas Section

One of the youngest Section Chairmen, Harold T. Johnson, was born October 1, 1921, in a small town in south Texas, El Campo, where he attended grade and high school.

▶ **1943 Graduate**—The first 2 years of Johnson's college education were obtained in Texas Lutheran College in Seguin, following which he entered the University of

Texas in Austin. He was graduated in January, 1943, with a B.S. in Mechanical Engineering.

While a student at Texas University, Johnson was a member of the local I.A.S. Branch and served as Chairman for 1 year. He is a Technical Member of the Institute.

▶ **Convair Engineer**—Shortly after his graduation, he was employed by Consolidated Vultee Aircraft Corporation's Fort Worth plant as Junior Stress Analyst. He has continued with Convair for the past $5^1/_2$ years and is at present Stress Analyst "A" in the structures group.

Living on University Drive in Fort Worth, Johnson's principal hobby is sailing, and he plays golf. He does some flying but holds no license.

Douglas Engineer at Cal-Aero Tech: *Guest speaker Robert C. Donovan (center), Project Engineer of Douglas Aircraft Company, Inc. (El Segundo), is greeted on his arrival by Chairman Robert J. Cameron of the Cal-Aero Technical Institute I.A.S. Branch (right), and Faculty Sponsor Abe Victor.*

Sections and Student Branches

Wichita Section

J. H. Gerteis, *Secretary*

At the Section's annual election of officers in August, the following were elected: Elton H. Rowley, Chief of Flight Test, Boeing Airplane Company, Chairman; Jerry H. Gerteis, Assistant Chief Engineer, Cessna Aircraft Company, Vice-Chairman; Herbert E. Dickard, Design Engineer, Beech Aircraft, Secretary; and George W. Baughman, Project Engineer, Cessna, Treasurer.

Aeronautical University

August 11 meeting, opened by Chairman A. C. McDermott, had as its guest speaker the Vice-President of the University, Mr. Burroughs, who spoke on the subject of "Recommendations for Eligibility Requirements for Extra-Curricular Activities."

Speaker at the August 18 meeting was Lewis M. Churbuck, President of the University, who reviewed the opportunities to be found in the aircraft industry and answered questions of the student body.

C. G. Sheker, Honorary Chairman of the Branch, lectured on the subject "Modifications on the DC-6" at the September 1 meeting.

Alabama Polytechnic Institute

The Branch held its last meeting for the Summer Quarter on August 10, with Richard Cousins, Chairman, presiding. Two films were shown: *Combat America* and *Jet Propulsion*.

Cal-Aero Technical Institute

With 127 in attendance, the meeting August 10 featured Robert C. Donovan, Project Engineer for Douglas Aircraft's D-558 Skystreak and Skyrocket contract. Robert J. Cameron presided as Chairman.

Mr. Donovan outlined the needs of the aircraft industry for transonic speed data, which led to development of the D-558 aircraft, and gave a discourse on engineering problems and

NORTHROP SIGNS FOR LOS ANGELES, SAN DIEGO BUILDINGS

Jack Northrop, national President of the Institute of the Aeronautical Sciences, and President of Northrop Aircraft, Inc., formally launched the building projects that will result in permanent headquarters for the Los Angeles and San Diego sections by signing the construction contracts late in August. Left, Mr. Northrop puts his signature to the contract for the $300,000 L.A. building. Looking on are (left to right): J. A. Brownlie (seated), of E. S. McKittrick Co., Inc., contractors; H. Roy Kelley, architect; B. G. Reed, I.A.S. Building Chairman; Willis M. Hawkins, Chairman, Los Angeles Section; Harry W. Strangmen, Chairman I.A.S. Contributors Committee; and Jim Straight, Manager, I.A.S. Western Region. Right, Northrop signs contract for San Diego's headquarters in presence of (left to right): Ben T. Salmon, Chairman of the San Diego Section; H. I. Mandolf, Chairman of the Contributors Committee; E. G. Stout, I.A.S. Councilman; E. P. Rhodes, Building Committee Chairman; and Jack Mason, I.A.S. Councilman. The L.A. building will occupy a 3-acre site in Hollywood and will house, in addition to an assembly hall with capacity of 500 persons, a reference library, conference rooms, lounge, and other facilities. San Diego's structure, to front along Harbor Drive, will contain an auditorium seating 350; a library, toward which Major Reuben H. Fleet donated $10,000; lecture room for small meetings; fully equipped kitchen; dining room; lounge and trophy room; fully equipped stage; and a projection room; in addition to an office for the Section and offices for use by other societies.

construction details of the Skystreak and Skyrocket.

Northrop Aeronautical Institute

A combined dinner and technical session was held August 12. Among the guests were Willis M. Hawkins, Jr., Chairman of the I.A.S. Los Angeles Section; James L. Straight, Manager of I.A.S. Western Region; Mr. Filson, Engineering Director of Northrop Institute; and two instructors of the institute, Messrs. Cate and Aubrey.

Student Chairman E. M. Prouty presided and introduced the new officers elected for the coming term. Officers are as follows: Chairman, R. R. Fisher; Vice-Chairman, D. Fix; Secretary, R. Hixson; and Treasurer, J. L. Taaffe.

Speaker of the evening, Willis Hawkins, presented the topic "The Designer's Problems and Groups He Must Cater To."

Parks College of Aeronautical Technology

An election of officers at the August 19 meeting resulted in the following: Chairman, Frank Steinke; Vice-Chairman, Charles Beckman; Treasurer, Robert Claude; Corresponding Secretary, Frank Wilcox; Recording Secretary, George Cote.

Spartan School of Aeronautical Engineering

A business meeting was held August 5 at which the Corresponding Secretary, Patrick J. Mango, presided in the absence of the Chairman.

Final arrangements were made for the August 8 outing, a special occasion on which members played baseball and football and pitched horseshoes.

News of Members

Edgar B. Beck has been with the National Advisory Committee for Aeronautics as Aeronautical Research Scientist since July, 1948.

Richard K. Becker is with North American Aviation, Inc., as Design Draftsman in the Aerophysics Laboratory, Downey, Calif.

Joseph N. Benezra is a student at CalTech, Pasadena, Calif.

Commander William J. Catlett, U.S.N., was recently ordered into the Military Air Transport Service as Chief of Training Branch, Air Transport Division, MATS Headquarters, Washington 25, D.C.

Group Captain Christopher Clarkson, R.A.F., is stationed at the British Embassy in Washington as Civil Air Attaché.

John M. Coan, Jr., who recently received his doctorate in aeronautical engineering at Brooklyn Polytech, has been named Associate Professor of Aeronautical Engineering at the University of Illinois.

A. C. Cordas is Senior Stress Analyst at Ryan Aeronautical Company, San Diego. He was appointed in the latter part of August.

Arnold E. Cowen is at Plant #2 of Fairchild Aircraft Division, Fairchild Engine & Airplane Corporation, Hagerstown, Md., where he is Aircraft Structures Engineer.

Fred J. De Meritte has been with Naval Ordnance Laboratory as an Aerodynamicist since August, 1947.

William C. Drake resigned the post of Aerodynamicist B at North American Aviation, Inc., in Los Angeles to accept appointment as Aeronautical Engineer at the Ames Aeronautical Laboratory, N.A.C.A., Moffett Field.

Arnold L. Ducoffe is Assistant Professor at Georgia Institute of Technology.

Herman O. Eley, Jr., is Research Engineer at Consolidated Vultee Aircraft Corporation in Fort Worth.

First Lieutenant John Wesley Farr has been assigned to the 308th Reconnaissance Group, Weather, Fairfield-Suisun Air Force Base, Fairfield, Calif. He is doing a 1-year tactical tour before returning to technical duties, flying specially instrumented B-29 aircraft to observe weather phenomena.

S. H. Fedan is with Koppers Company, Inc., Metal Products Division, Baltimore, as Manager of the Aeromatic Propeller Department.

Clarence C. Flora has been named Instructor of Aeronautical Engineering at Rensselaer Polytechnic Institute, Troy, N.Y.

Peter G. Franklin, former Air Force pilot, is attending college. He lives in Mill Valley, Calif.

Harry F. Frissel was named Associate Professor of Physics at Hope College last September 7.

Stuart J. Fuller, Jr., has received the S.M. degree in Meteorology from Massachusetts Institute of Technology. He is a Physicist at the Naval Ordnance Laboratory at White Oak, Md.

James Gaz is Ordnance Engineer at the Naval Ordnance Plant in Indianapolis, Ind. He was appointed last August.

William T. Hamilton is an Engineer with Boeing Airplane Company. He joined the company last August.

B. H. Hasselbring is a Power Plant Engineer with Engineering & Construction Division, Tulsa, Okla.

William S. Hough has been with Johns-Manville since April as Assistant District Manager in Chicago.

William C. House is with The General Tire & Rubber Company of California as Research Engineer working on gas turbines.

Arlo F. Johnson is at Stanford University studying for a Ph.D. degree.

Paul G. Johnson accepted a position as Aerodynamicist B with Consolidated Vultee Aircraft Corporation, Fort Worth, Tex.

Robert F. Kahn, who resigned as Project Engineer with the Edo Corporation, is now Structures Engineer with Research Department, United Aircraft Corporation.

Thomas C. Kavanagh is at The Pennsylvania State College as Associate Professor of Civil Engineering.

(*Continued on page 86*)

Greets Air Chief of Staff: *George H. Scragg (left), retiring President of the Early Birds, welcomes Gen. Hoyt S. Vandenberg, Chief of Staff, U.S.A.F., one of the principal speakers at Early Birds' Annual Banquet in Cleveland.*

6242 Sent out

1906 Returned by 22 Sept

AERONAUTICAL ENGINEERING REVIEW

Readership Survey

Please signify your opinion of the AERONAUTICAL ENGINEERING REVIEW and its component sections by a check mark and as otherwise indicated in the appropriate spaces below:

1. General

a. Do you read the Aeronautical Engineering Review?

Thoroughly 26.5 ☐ Spottily 72.5 ☐ Not at all 1.0 ☐ ← percent

b. Do you retain the Aeronautical Engineering Review for future reference?

Yes 69.3 ☐ No. 30.7 ☐

2. REVIEW Sections

a. What departments of the Aeronautical Engineering Review interest you most?
(Check three in order of choice below)

15.5 percent

45.5

Department	1st Choice	2nd	3rd
I.A.S. News	☐	☐	☐
Feature Technical Articles	☐	☐	☐
I.A.S. Briefs	☐	☐	☐
Aeronautical Reviews	☐	☐	☐
Books	☐	☐	☐
Editorial	☐	☐	☐

24.0

3. Remarks

a. Is the Aeronautical Engineering Review sufficiently broad in scope and subject matter to maintain your interest? Yes ☐ 79.7 No ☐ 15.3

b. What do you recommend to improve the value of the Aeronautical Engineering Review to you?

See Editorial opposite for some comments —

(Use back of sheet for further remarks)

4. Please list your specialty in the aeronautical field:

404 Returns in this Sampling.

Editorial

We Asked for It!

—And, thanks to the splendid cooperation of the members of this Institute, we got what we wanted!

Several weeks ago all active Institute members received in their mail a copy of the questionnaire reproduced on the opposite page. We sent out some 6,000. As of the date of going to press with this issue, we have had replies from over 1,900 members, a 30.5 per cent return. This in itself is a rather extraordinary achievement. Most commercial and trade magazines think that they are doing extremely well to score a much smaller return on such a survey.

The volume of the return shows an encouraging interest in the Institute and its publications. But that is not its most significant feature. Most gratifying is the careful thought that obviously was given to the questionnaire and the intelligent and critical analysis that went into the preparation of the replies. A high percentage of Institute members took the time and the trouble to give us the benefit of their views at length, sometimes for several extra pages. These notes comprise one of the most valuable results of the survey, for they contain many well thought out suggestions for our future guidance—exactly what your editors had hoped to secure.

As of this writing, the final tabulations are not complete. Returns are still coming in at a rate of 40 to 50 a day. To get a preliminary indication of trends, however, a random sampling of over 400 questionnaires was made on September 22. The general results of this sampling are indicated on the facsimile on the opposite page. They give some indication of what may be expected for the final results. In a later issue, we will publish the final score in complete form.

Comments from the sampling ranged all the way from curt suggestions of "save our forests—save paper — discontinue publication," up through the highest type of praise, "no complaints," "highly satisfied," "very good as is." (We are glad to report that only 3 out of the 404 of the sampling were in the first category, or even approached it.) Such extreme comments, either way, were the least valuable to us. In between, there is a wide range of sound and excellent suggestions that will provide us with much food for thought. Our entire editorial staff is studying every one of them carefully, weighing each in the balance and considering each one in terms of future planning for the REVIEW.

The management of the Institute and its editorial staff wish to extend sincere appreciation for the help that we have been given by the members through the survey. We now have a much clearer understanding of what you want in your magazine. And it is *your* magazine. Its only reason for existence is to serve your professional interest to the best of our ability.

S. P. J.

Naval Aviation

and the Influence of Its Mission on Carrier-Based Aircraft

By

REAR ADM. T. C. LONNQUEST
U.S.N.*

Introduction

THE MAIN OBJECTIVE of the National Military Establishment—and the primary reason for its existence—is the security of the United States, which involves maintenance of peace in the world. Under the National Security Act, the strength of our national defense lies in well-balanced, integrated air, land, and naval forces, mutually dependent and working together, with unity of purpose, as a single irresistible fighting team.

In the presentation of this paper, I have set myself three tasks: first, to describe the role of sea-air power in relation to the overall aspects of national defense; second, to summarize the influence that the mission of carrier-based aviation exerts upon the design requirements for the aircraft it utilizes; and third, to be as brief as a subject of this scope will permit.

Preliminary Considerations

If any doubt existed prior to World War II, the latter made it abundantly clear that the first requisite for success in military or naval operations is air supremacy.

Circumscribed and handicapped by technical limitations, air power in World War I provided no more than a hint of its tremendous future potentialities.

In World War II, air power came magnificently of age, and the record of its accomplishments all over the world is a tribute to the fighting spirit, the courage, the sacrifices, and the technical competence of those who forged and utilized and supported this most formidable agency of war.

Lest we be lulled into any false sense of security, however, any feeling that national survival is now a quick and easy task—a mere matter of ringing up on the cash register the correct number of airplane groups—it is well that we understand the full implications of the lessons of the last war.

Official U.S. Navy Photograph

Rear Adm. T. C. Lonnquest, U.S.N.

Behind the record of stupendous destruction established by air power emerges another aspect of great significance—the recuperative powers, the dogged will to resist, and the extraordinary durability under conditions of war damage displayed by certain nations during the past war.

The Battle of Britain, as a demonstration of courage, of resilience, and of inextinguishable determination to perform the impossible in the face of everything that the German Air Force could deliver, was an epic on everyone's tongue in the dark days of 1940 to 1942.

In Germany, where comprehensive postwar studies have been accomplished, it is estimated that some 1,400,000 tons of bombs were dropped, destroying or significantly damaging nearly a million buildings, killing some 300,000 persons, and wounding 700,000. Bombs released against Germany are estimated to have cost 12 billion dollars or $3^1/_2$ million Allied man-years, knocking out German productive effort to the tune of some 5 million man-years.

In spite of this, however, German aircraft productivity reached a peak in 1944, and the durability of the German people to air attack is significant. The Strategic Bombing Survey uses these words:

> "Under ruthless Nazi control, they showed surprising resistance to the terror and hardship of repeated air attack, to the destruction of their homes

* Bureau of Aeronautics, Navy Department.

and belongings, and to the conditions under which they were reduced to live. Their morale, their belief in ultimate victory or satisfactory compromise, and their confidence in their leaders declined, but they continued to work efficiently as long as the physical means of production remained. The power of a police state over its people cannot be underestimated."

Much more might be said against underestimation of the problems of another war, should it come. Faster bombs, higher altitudes for operation, the potentialities of the atomic bomb, all increase the power of the air offensive, but the problems that confront it are increasing, too. The proximity fuse, the jet interceptor, the short-range antiaircraft guided missile, improvements in radar warning systems—all reflect the ingenuity of science, historical in warfare, in producing countermeasures and in strengthening the defensive aspects of air power.

And finally, in weighing the relative positions of air offense and air defense, a variety of indications suggest that significant parts of the vast complex of overseas air bases so essential to air operations in the past war may not be available to support our operations in the next, unless and until we fight for them. The corrollary to such a contingency is that shore-based aircraft may, for a time at least, be faced with the necessity of operating under greatly extended range requirements, with all the technical penalties and tactical problems that such a situation entails.

Not to minimize the dominant role that air power plays in the preservation of peace, the point here is that we must guard against an overoptimism that might fail to recognize the true magnitude of the overall problem that confronts us in the event of another war.

The first, and by far the most valuable, aid that total effective air power in being can render to this country and to the world is to prevent war from occur-

DECK-LOAD OF DISASTER—FOR JAPS! **Its flight deck thronged with warplanes (Grumman Hellcats, Curtiss Helldivers, and Grumman-designed, General Motors-built Avengers), this U.S. Navy aircraft carrier of the "Essex" class moves through the Pacific as part of a Task Force enroute to smash at the Japs. Astern are other carriers in the Force—a sister ship of the "Essex" class in the lead, followed by light carriers.**

Official U.S. Navy Photograph

ring—this, by threat of instant and devastating retaliation.

Important as is this threat of retaliation, it is, as I hope to show later, only the first of several major aspects of overall national defense. We must not fail to recognize the essential fact that, should war occur, it will demand the absolute maximum of coordinated national effort from the military, from industry, from science, and from the nation at large.

In particular, it will not be won by a single type of weapon nor a single agency alone. On the contrary, it will require every significant weapon and every element of teamwork that can effectively be brought to bear upon our proper military objectives.

For our purpose in describing the coordinated relationship between sea-air power and the overall aspects of national defense, it might be helpful to outline broadly the major operational aspects probable, or likely to appear, in a war of the near future. Before doing so, however, certain basic elements that provide a framework of reference for the problem as a whole warrant consideration.

Basic Elements

The first basic element is the premise of *retaliatory* war. Popularly and glibly, this tag has been used to identify a concept of war of the future, but we should understand that the term has a somewhat specialized meaning.

What we do *not* mean, is reprisal in kind—an eye for an eye and a tooth for a tooth.

Rather the meaning is this: that, appropriate to our democratic ideals, our nation has in the past shown a reluctance to strike military blows until after significant overt action on the part of an aggressor nation.

As an antidote to an ideology of Pearl Harbor type of treachery, we propose a condition of instant and effective readiness.

We must recognize, however, that acceptance of such a philosophy entails some of the elements of beginning our active war looking into the gun barrel of an antagonist who will already have taken initial steps to damage our military position and that of our potential allies.

A second basic premise is that we are committed to *global war*. By this we mean that the nature of air power upon which our National Defense is built gives it wide freedom from the limitations of topographical barriers, subject only to the problems of radius of action and all weather capabilities. This freedom of action, available both to ourselves and the air force of a potential enemy, entails a dual responsibility—first, that we be able to reach into every quarter of the globe to exploit the potentialities of air power where appropriate to our military objectives, and, second, that we be competent to deny such freedom to the enemy, again in every quarter of the globe.

And that brings me to a third basic element, as a sort of corollary to the second—that we must be prepared for an *oceanic war*. It is no depreciation of the capabilities of air power to point out that the facts of geography remain unchanged, that broad and very wet oceans surround the more accessible boundaries of our continent, and that the freedom from the limitations of topographical barriers enjoyed by air power does not extend to a variety of other transport vital to our war effort.

As a highway over which our war essential commerce can move and as a buffer in depth which forces enemy air attack to long overseas flights with all the attendant penalties on range and performance and risk of interception by our own sea-based air power, these oceans are an asset.

As cover that may provide concealment for the enemy submarine to our very coastline, the oceans are a liability and an acute responsibility.

In brief, all the elaborate mechanism entailed in the problem of fending off war from our shores and transferring it to the homeland of the aggressor demand recognition of our oceanic position and the importance of sea power in the broadest sense of the latter.

A fourth and obviously major basic element is the matter of the *atomic bomb*, which requires the evaluation of a host of imponderables.

The tremendous destructive power of the bomb is beyond challenge.

Written in the record of appalling destruction at Hiroshima and Nagasaki and in the implications of such information as has been made public about subsequent tests, its technical potentialities establish the atomic bomb as a weapon that overshadows all others in planning for national security.

Neither this unquestioned fact nor its use by the United States under special circumstances in World War II necessarily identify the atomic bomb as the best weapon for every tactical situation that might arise in a future war. Abstinence by all belligerents in World War II from the use of poison gas may be cited as an example of careful handling of a weapon that could react powerfully on victor and vanquished alike.

Nor would our planning for offensive or defensive action be the same today as 2 or 5 or 10 years hence.

Time does not permit the detailed examination which this very important subject deserves, but there are certain conclusions which seem relatively clear. First, the real hope of the future lies in rationalization of the problem on an international basis, with control of the atomic bomb vested in a body similar to the United Nations. Second, pending such a solution, the U.S. will for a limited time retain a monopoly on the atomic bomb. This monopoly will last for only a few years, however. Third, our defense mechanism must be organized to provide at all times the maximum practicable degree of security against atomic attack in any form. And, finally, our plans for the military security of this nation must be of sufficient flexibility to include not only the means to achieve victory with conventional armaments but to gain that objective by the use of such other weapons as circumstances may dictate.

Official U.S. Navy Photograph

Navy Grumman Hellcats move forward in line on the deck of a carrier to take off for a strike against Manila Bay. Plane handlers pass signals to the pilots of the planes as the take-offs get under way.

Major Operational Aspects

So much for the background. Now to come to more concrete cases. If we are unable to prevent war from occurring, what general form will it take? What are the major operational aspects likely to appear in a war of the near future?

Continental Defense

Broadly speaking, and recognizing the inevitably kaleidoscopic nature of modern war, there are four major operational aspects of concern to us.

The first and most vital of these is *continental defense* —the protection of our citizens and the security of the United States as an arsenal and base from which to launch aggressive offensive action.

The strategical concept for which our defense must be prepared is that attack will come without warning and that it may involve a variety of weapons, including the atomic bomb.

In the civil field, our country must prepare for sabotage, possibly with atomic weapons and attempts to incite class warfare.

In the military field, we must anticipate enemy air bombing and air-borne troop attacks, capitalizing in part, perhaps, on surprise seizure of intermediate bases. At sea, we may expect the appearance along our coasts of enemy submarines launching guided missiles. Our objective here, as previously implied, will be instant readiness for action before action becomes necessary. Secretary Symington, in a recent magazine article phrases it as follows: "The safety of the United States

Official U.S. Navy Photograph

FIRST OPERATIONAL JET FIGHTERS TAKE OFF AND LAND ABOARD AIRCRAFT CARRIER.—Two in a series of four. Above photograph shows the tricycle landing gear of the Fury. Here it speeds down the flight deck a few lengths before becoming air-borne. As in conventional aircraft, the plane takes off and lands under full flaps.

demands that we have an impregnable air curtain—a curtain sufficiently strong so that no fleets of hostile planes or waves of guided missiles can reach the mainland of this country."

And, finally, and of comparable importance, we must have alertness and readiness not only in the continental United States but also far off shore—defense in depth where naval planes will combine with our own submarines to detect by radar and intercept approaching enemy aircraft or to forestall the seizure of intermediate bases vital to his purposes.

Long-Range Air Assault

Touched off by the first attack on the United States and continuing throughout a war, a second major operational aspect will instantly arise—*long-range air assault*. Definitions vary, but under the general long-range air power category might be included strategic bombing and air-borne troop expeditions. Strategic air warfare is a primary function of the Air Force.

Obviously, solution of the problems associated with long radius of action and high performance are of particular interest in this operational aspect, but the extent to which operations in this category would rest on sorties from the United States would depend in some measure upon action that the enemy might take in the initial phases of the war toward seizure or neutralization of bases overseas.

Projection of Our Military Power Overseas

The important question of overseas bases brings us to a third major operational aspect, which I have termed *projection of our military power overseas*—operations intended primarily to bring us into closer tactically offensive grips with the enemy and to follow the classic American pattern of carrying war to the soil of the aggressor.

These efforts fall into two general categories. The first is amphibious operations executed in conjunction with the Army and the Air Force, with the general objective of seizing overseas bases from which land-based aircraft may operate with the improved effectiveness that comes from shorter ranges or bases that may serve as beachheads for ground troops.

Overseas movements in this category will be characterized by the employment of air power in close integration. Enroute, enemy opposition will manifest itself principally in the form of submarine activity.

When in closer proximity to the enemy, air operations will become of major significance, and carrier-based aviation, spear-heading the amphibious operation, will have as its objective the establishment of local air superiority over the enemy and can provide the prolonged close support to ground troops so essential during the assult phase.

The second general category in the projection of our military power overseas is the exploitation of naval carrier-based air power, which operating from its own mobile base, can provide not only the air effort to support the seizure of beachheads and advanced bases just mentioned but can also strike major blows on its own account—a phase to which I shall return shortly.

Antisubmarine Warfare

A fourth major operational aspect that any conflict of the future will most certainly involve is *antisubmarine warfare*.

I have already indicated the importance that seaborne transport may play if we desire to project our military power overseas, but there is another aspect of comparable importance—the maintenance of our supply of raw material. All of us who struggled with production in World War II will recall the critical nature of the problems created by material shortages. It is imperative that we keep that lesson firmly in mind. We are not self-sufficient now in many of the basic necessities of both peace and war. We never have been, and our dependence upon water-borne, overseas shipments is constantly on the increase. Manganese, tungsten, chromium, tin, and lead are only a few of the vital imports that must flow without interruption and in vast tonnage to our factories.

In World War II the total Atlantic and Pacific overseas transportation job for the Army, Navy, and Merchant Marine reached the staggering figures of 33 billion passenger-miles and 676 billion long-ton-miles of cargo. These are the targets of the submarine.

Dangerous as the submarine was in two previous wars, the submarine industry has been just as keen as the aeronautical or any other industry in capitalizing upon advances in new technology to produce radically new and even more deadly types, capable of deep submergence and high submerged speeds that make detection and countermeasures extremely difficult. More-

over, to all the former capabilities of this menacing creature as a commerce destroyer has been added the ability to launch guided-air-borne missiles.

Most definitely, the submarine is a weapon to be reckoned with in the future as never before, and its destruction promises to be one of the major operational aspects of the next war.

Role of Carrier-Based Aviation

So much for a quick glance at some of the major operational aspects likely to appear in a fast-changing variety of combinations in a war of the near future. Throughout a wide diversity of situations, the Navy as a whole and Naval Aviation in particular may be expected to play a vital role, but I propose to limit further comments to that specific part of Naval effort represented by carrier-borne aviation. Let us begin with a look at a Carrier Task Force—its characteristics and its capabilities.

Description of Carrier Task Force

Naval air power is the heart of the Navy, but to project the full impact of that potent force against the enemy, over a vast area of the globe whenever and wherever required, necessitates the creation and use of a highly specialized vessel—the aircraft carrier.

With a flight deck some 900 ft. long, complete with catapults and arresting gear, the carrier provides every facility of a complete air base. Fuel storage, facilities for rearming, for service and maintenance, quarters for personnel, antiaircraft defense, communications and control—the carrier supplies all the complex operational needs of the embarked air groups. And to capitalize fully upon the potentialities of the aircraft carrier it must be assembled with other carriers and support vessels into tactical organizations, tailored, balanced and appropriate to the task to be performed. This is the Carrier Task Force.

Principal Characteristics

Taken together—air groups, carriers, and supporting ships—the Fast Carrier Task Force is an air striking force of tremendous power and unique versatility. Its most outstanding characteristic is, of course, mobility from which flows a number of military virtues of great importance:

It provides the ability to *maintain secrecy* and to use the *flexibility* of rapid movement to *concentrate* and effect *surprise.*

Mobility promotes *economy of force* and provides means for the establishment of a state of instant *readiness* in selected off-shore parts of the globe—a sort of global flank security, which may be vital to our national interests.

But overlapping many of these military virtues, mobility of the carrier task force provides one other advantage of transcendent importance—namely, *range* in striking power of its embarked aircraft. The essence of air power is the ability to control and utilize the air for whatever purposes and in whatever area may be required, while denying such freedom to the enemy. As a corrollary, it requires the ability to bring enough of the right type of weapons into effective action at the right time and at the needed geographical location, which may be anywhere in the world.

Stated another way, air power to be useful today is a combination of two agencies: first, bases so located and, second, airplanes so designed and fueled, that the specific type of airplane required for any particular vital purpose can reach and perform its mission at any point where it is needed.

It is this problem that points up the unique value of carrier mobility. To the Carrier Task Force, the sea is not a barrier but a highway to the shores of island continents all over the world, a highway that enables it to put into the air in strategically critical parts of the globe a tactical air force of higher performance than could fly into those same critical locations from more remote shore bases. This free transportation to the combat area underlies a general principal of great importance—that, when you mount any weapon on a Naval ship, you increase the effective range of that weapon by some part of the cruising radius of the ship itself. In other words, 800 miles of radius built into the tanks of the airplane can be supplemented by perhaps 3,000 miles of radius in the form of transportation in kind, supplied by the carrier from which it operates.

Range extension, then, is one of the major rewards generated by the mobility of the Carrier Task Force.

Capabilities

Now how do these general military virtues, springing out of mobility, relate to specific missions in support of the four operational aspects which we identified earlier? First and fundamental to its usefulness, the Carrier Task Force has *sea-keeping endurance.* This proved ability to stay on the job for extended periods springs in

Official U.S. Navy Photograph

JET-ASSISTED TAKE-OFF FROM CARRIER DECK.—Catapulted by JATO (Jet-Assisted Take-Off), a carrier-based TBM Eastern Aircraft Avenger wings out over the waters of the Pacific.

part from basically correct ship design and in part from the ability to refuel and rearm at sea. As a strictly normal procedure, replenishment of every kind—material, personnel, and air groups—is accomplished at sea, completely adequate to keep the task force in a fully operational status for long periods running into months.

Closely related to the general question of ability to stay on the job is the matter of *resistance of carriers* to enemy attack. The strength of the Carrier Task Force in self-defense rests in three elements. It protects itself first and foremost with its own aircraft, which it can muster in powerful local concentrations appropriate to the expected air opposition. The use of jet aircraft of improved and specialized types, together with advances in the science of radar detection, promises a continuing increase in defensive strength. Massive concentrations of antiaircraft fire provided by the carriers and their screens is a second defensive element. And finally, the power of movement, the ability to be here today and 600 miles distant 24 hours hence, to take evasive action at high speed, or to disperse a formation in a matter of minutes—all are protective maneuvers so effective as to render a task force an unprofitable target even for an atomic bomb.

In the last war we operated 110 aircraft carriers of all types for a total of some 940 months in combat areas and lost eleven—statistically, one for each 85 months of exposure to enemy attack. Analytically, the record was even better. After the incorporation of mechanical improvements, and the use of new tactical doctrines resulting from experience gained during the first year of the war, Fast Carrier Task Forces met everything the enemy had to offer and lost only one large carrier during the remainder of the war.

In its *offensive* role, the effectiveness of the Carrier Task Force arises, as we have previously stated, from its ability to exploit the combined range, power, and mobility of ship and airplane.

To digress for a moment, the special operational problems of the Anti-Submarine Carrier Task Force are somewhat different. You do not destroy a modern submarine as you would a surface vessel—with a single triumphant swoop. On the contrary, the schnorkeling submarine with its additional capabilities of deep submergence and high submerged speeds presents a task that depends fundamentally upon continuity of effort—dogged and persistent teamwork between surface vessels and highly instrumented aircraft, the latter, in turn, so closely supported by an aircraft carrier as to ensure uninterrupted and unrelenting on-the-spot effort.

In contrast to the subsurface preoccupation of the Hunter-Killer Groups, the Fast Carrier Force is fully capable of accomplishing the wide variety of missions essential to the effectiveness of air power at sea.

Without spelling out all the tasks for which the services of Carrier Task Forces may prove indispensible, its role might be summarized from my earlier comments in two words—interception and attack

In the first role, and in addition to antisubmarine warfare, the Carrier Task Force, by surveillance and by striking power far off shore, can prevent the movement of enemy forces intent on establishing the interim bases that might provide the staging points for attack on our homeland, or, operating with our submarines, it can detect and intercept enemy aircraft raids.

In a larger sphere, its offensive capabilities fall into three categories: first, those concerned with the dislodgment of enemy forces or the seizure of advanced bases or those generally comprised under the term of amphibious operations; second, precision strikes by carrier-based bombers supported by accompanying escort fighters against vital and specific elements of the enemy's target system; third, concentrated fighter sweeps to destroy the enemy's air strength at its source.

Influence of Mission on Carrier Aircraft

These capabilities are, of course, among the inescapable minimum responsiblities expected of any air force. The important point is not that sea-based air power can execute these tasks but rather that it can perform these tasks over a wide area of the globe and that they can be initiated beginning with the earliest moments of war, before shore bases of comparable proximity to the enemy could be seized or readied.

This outline of the role of sea-air power within the overall framework of national defense brings us to the next point—namely, the influence of the environment created by air operations from mobile, sea-going bases upon the aircraft employed. Three aspects of this environmental problem might be noted, not in terms of detail specifications but rather in broader overall objectives.

Problems of Carrier Environment

The initial phase of the overall problem is the *environment created by the carrier* itself. The merit of an aircraft carrier—which forms the springboard from which naval aviation strikes—is measured by its ability to operate the maximum number of aircraft with maximum facility and dependability. Accordingly, the environmental characteristics of the carrier-based plane must be such that it can be accommodated afloat not only without sacrifice of its own performance in the air but also with minimum interference to the overall effectiveness of the carrier. The problem springs obviously from the extreme limitations on space aboard a carrier as contrasted with the generous acres of a shore base. As a result, a fundamental objective in every development project for carrier aircraft is the creation of a design that will permit a scientific and operationally practical concentration of the maximum number of aircraft in a minimum of precious square feet of deck area.

Extreme awareness of the importance of compactness in design and the significance of key dimensions is, however, only the beginning. Efficient operation de-

mands that the airplane must be ready for relaunching at the earliest possible instant after landing. This entails special arrangements for securing and for handling aircraft on a pitching deck; for rapid fueling and rearming; for last-minute checks and line maintenance; for engine run-up, both jet and propeller; and for defueling.

Moreover, these arrangements must be effective—all of them—under the pack-jammed conditions of a typical deck spot, with wind over the deck of 30 knots or more, where a "dud" airplane, unable to take off with instant readiness, may momentarily throw the whole team out of its precise timing.

The emphasis on the development of special airplane design characteristics to overcome the limitations of space on board a carrier becomes of special importance in the landing and take-off phases of operations at sea. First is the matter of the special aerodynamic features of design and performance which promote short take-offs and which provide the precision of control in low-speed flight required for accurate landings in the arresting gear of a pitching ship or for a safe "wave-off" during the last split second of the approach phase.

Second, but of almost equal importance because of the extreme significance that attaches to the day-after-day availability of carrier-based aircraft, is the requirement for built-in strength and ruggedness, adequate to ensure that every part shall withstand the shock of continuous carrier operation and with every structural element precisely proportioned to minimize impairment of performance in the air.

Every airplane is, of course, a matter of design compromises. I would emphasize, however, that it is a guiding policy in the Navy to relieve the airplane of the special burdens resulting from carrier operation and to transfer these burdens to the ship, in order that the latter may supply the maximum assistance possible so that on the other side of the ledger there are already real operational advantages in some aspects of the environment afforded to the airplane by the ship.

Anywhere off soundings, the carrier can turn its flight deck into a wind of its own making greater than 30 knots. Moreover, its planes, when launched, are already above the classic 50-ft. obstacle clearance by virtue of the height of the deck above water. Nor are these improvements at an end. Where the shore-based aviator may be getting landing field improvements in the form of longer and thicker runways, the service afloat will be developing faster ships and more powerful catapults and stronger decks and arresting gear of greater capacity. It is true that air operations from mobile bases present fundamental problems of considerable difficulty. The important point is that, in the hands of an aircraft industry skilled, experienced, and constantly exercised in the Navy's special problems, the conditions provided for aircraft by the environment of a carrier not only will not be crippling but indeed have many favorable aspects that the operator on shore would eagerly welcome.

Environment Imposed by Combat Operations

Solution of the problems presented by the environment of operation on board a carrier is unfortunately only the initial or preliminary aspect of the overall environmental problem—only the introduction to a far more exacting régime that the airplane must encounter when it lifts off the deck and climbs to the *environment imposed by combat operations*. The Carrier Task Force undertakes to deliver the airplane, with fuel tanks full and with the pilot fresh and rested, to almost any quarter of the globe accessible by sea. It spares the pilot the fatigue and the penalties on performance incidental to flying into the theater of action from remote bases. Once the carrier pilot is air-borne, however, he is strictly on his own, and the *performance* of carrier-based aircraft thereafter must in every way match or surpass that of their adversaries.

Obviously enough, under conditions where battle competition is the keynote, airplane characteristics dictated by the combat operational environment will be essentially the same for comparable types, whether carrier-based or shore-based. The tactical procedures employed by carrier-based aircraft for utilizing those characteristics will, however, develop certain special problems for the designer of carrier aircraft.

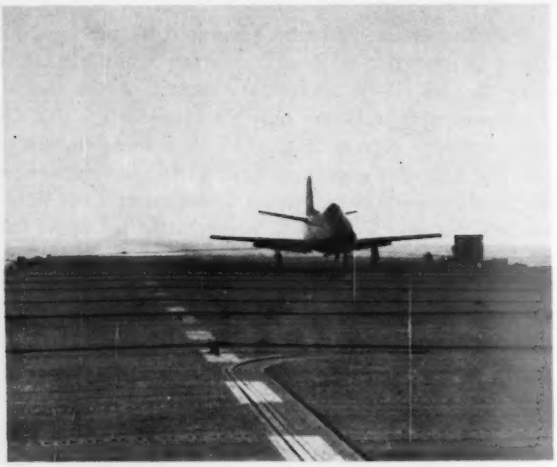
Appropriate to the tasks for carrier aircraft which we previously discussed, two principal categories of aircraft are embarked to provide the air strength of carriers: fighters, whose primary targets are other aircraft in the air, and attack aircraft, which concentrate primarily on surface objectives and can deliver smashing blows with bombs, torpedoes, rockets, or guns.

Time does not permit a detailed review of the effect of carrier air group tactics on the design requirements for these aircraft, but certain typical examples might be noted. These fall into two categories: first, a growing need for specialized aircraft subtypes; second, the incorporation of special features within standard aircraft types.

As an example of the first we might point out that the Navy's basic doctrine of providing fighter protection to accompany attack aircraft on their missions creates two problems: first, a constantly increasing demand for radius of action in the escort fighter adequate to match that of the inherently longer radius attack planes; second, the problem of reconciling the somewhat incompatible cruising régime of jet fighters with that of the propeller-driven attack aircraft in order to produce a tactically homogenous air striking group.

Again, in the fighter category, special problems of carrier defense and of all-weather effectiveness will find their respective solutions in an intercepter type particularized for carrier employment and in a fighter type exploiting the potentialities of electronics to a maximum.

Nor can the wide variety of *special features* required in standard Navy types be provided as an afterthought. The attack airplane exists for the purpose of delivering a load of munitions—bombs, rockets, missiles or gun-



Official U.S. Navy Photograph

FIRST OPERATIONAL JET FIGHTERS TAKE OFF AND LAND ABOARD AIRCRAFT CARRIER.—Four in a series of four. Here the FJ-1 Fury has just come to a stop after hooking onto the first wire at the after-end of the flight deck.

fire—to the enemy, but effectiveness in the combat environment must be engineered from the first with due consideration of the necessity for shipboard servicing, for air-frame compactness, and for catapult launching.

Vertical or near-vertical dives favored by the Navy for precision dive bombing and for a variety of fighter operations are another example of tactics in the combat environment which create special design problems. Diving tactics require speed-stabilizing equipment in the form of *dive brakes*, the latter entailing design requirements of a most exacting nature—high-speed actuation against powerful forces, positive synchronization, minimum adverse aerodynamic characteristics—just to mention a few.

To cite one more example of special problems under combat environment, the *field of electronics* receives substantially different form of emphasis in carrier-based operations. Alternate landing fields are few and far between on the blank expanse of the ocean, and electronic aids are vital not only for such routine aspects as communications and collection of intelligence for attack and defense but for navigation and rendezvous under the special conditions of a moving base and absence of landmarks. Most emphatically electronics assumes a whole new order of importance for control and recognition of combat traffic when the latter approaches the fast maneuvering, highly sensitive and massive anti-aircraft defenses which constitute so significant a part of the Fast Carrier Task Force. And finally, all-weather operation, the basic goal of naval aviation depends to a major degree upon progress in electronics.

Environment for the Pilot

The two aspects of environment that have been discussed up to this point—carrier environment and the environment of the combat zone—represent external conditions imposed upon the airplane, conditions that the designer has met with great effectiveness.

The third and final aspect is the *environment that the airplane must supply for the human pilot*. This aspect the airplane designer views with far less satisfaction, primarily because of his inability to effect improvements in the human pilot in the same manner that he has improved the airplane. Correctly enough, the airplane designer points out that the human pilot weighs just as much now as he ever did, takes up just as much precious space in the airplane, and will die if hit on the head with the same size rock that would have killed a man 1,000 years ago—maybe smaller. Man does not improve the way the airplane does, and worse than that he shows little promise of doing so. In addition, he complains if he is too hot or too cold and passes out if the airplane maneuvers too violently or if you fail to provide him with oxygen. He gets lost. He gets tired and loses his ability to concentrate, and he has nowhere near the sensitivity and rapidity and precision of response which the airplane designers see are going to be necessary in the future.

It is true that the human pilot is being scientifically and objectively studied and that aviation medicine is producing amazing new facts every day as to his limitations, how to protect him, and how to get the most out of his capabilities, but when all is said and done he will still fall far short of what the airplane designer would like to get from him.

So careful consideration has to be given to his frailties and to the creation of devices for facilitating the pilot's ability to cope with his heavy responsibilities in high-speed flight and all-weather operation of the future.

Cockpit Environment

Briefly, three categories of these devices are required in an airplane. The first category furnishes the human pilot with an environment in which he can live—that is to say, a cockpit that provides pilot tolerable conditions of atmosphere and protections against physical injury from accelerations.

Two factors are involved in the matter of pilot's atmosphere, temperature and pressure. As to the former, we used to be concerned primarily with the matter of keeping the pilot warm against the subzero temperatures of the higher altitudes. Now, however, we are equally concerned about keeping him cool against the various heat sources to which he is subjected. Aerodynamic heating from high-speed flight, heat from jet engines, heat from solar radiation—from these and a variety of other sources comes the necessity for replacing our former simple cockpit heating system with a complete cockpit air-conditioning system to provide either cooling or heating.

Relatively simple and reliable oxygen apparatus will take care of the pilot's requirements up to about 40,000 ft. Above that altitude pressurized cockpits are required. This is not the complete answer to the problem of cockpit atmosphere because of the hazard of explosive de-

compression—a phenomenon that results from sudden pressure drops such as would occur if the cockpit enclosure was lost or shattered by gunfire. Explosive decompression can cause serious injury to the pilot and can be kept in hand only by placing strict limits upon the pressure differential allowed in flight.

The remaining major device in this category is the anti-*g* suit to delay the onset of blackout resulting from the effect of high radial accelerations on the pilot's circulatory system. The average human can tolerate for a short period about 5*g* positive radial acceleration—the acceleration developed in a turn or in the pull-out from a dive. The anti-*g* suit will increase that tolerance by about $1^1/_2$*g*, an important factor in the current emphasis on high-speed flight.

Extension of Human Sensitivity

The next category of aids to help the human pilot keep pace with his responsibilities is the host of vital components which relate to automatic control and to an extension of human sensitivity and perception.

Far beyond the simpler concepts of the past, the overall objectives of this new automatism is to supplement and, in many tasks, replace, human perception, judgment, and response in the mechanics of flight by the multiplied capabilities, sensitivity, and precision of electronic apparatus, in order that a highly complex flying machine may be directed by simple overall commands, thus permitting safe flight that otherwise would be beyond the capabilities of human pilots because of distortions of the geometry of space and time created by this new régime of speed.

Pilot Escape

The third and final category of devices under development to aid the human pilot is a very human one indeed. Closely related to other phases of cockpit development, it deals with the matter of pilot escape from high-speed aircraft in flight in an emergency. To our present thinking, conventional methods of bail-out for safe escape in an emergency are limited to speeds below 300 m.p.h. Solution of the problem of escape at higher speeds resolves itself into providing positive mechanical means for separating the pilot from the airplane in an emergency and at the same time protecting him against damaging forces.

We have divided our attack upon this problem into two phases: first, a method for speeds of the order of 500 m.p.h., and a more elaborate method for higher speeds.

In the first method, the pilot and his seat are catapulted by a small powder cartridge upwards on vertical guide rails and out through the upper side of the cockpit. The seat and pilot are ejected high enough above the fuselage to clear the tail of the airplane, where the pilot releases his seat and descends by means of his regular parachute. Although development is not complete, extensive ground and flight tests show great promise.

For speeds above 500 m.p.h., a program is in progress for development of design criteria for the so-called capsule-type escape. In this scheme, already described in the aviation press, the forward portion of the airplane containing the pilot is detached from the airplane and the pilot subsequently releases himself from the nose section and descends by parachute. Although the initial problem of mechanical separation of the forward shell from the remainder of the airplane has been effected, numerous others still await solution or verification: the effects of deceleration on the pilot, possible collision of the capsule with the airplane, how to stabilize the capsule after jettisoning, how to provide for final pilot escape and the special survival equipment which he may need, just to hint that the list of unsolved problems is perhaps more formidable than those already solved.

Among the many other items associated with the general subject of environment for the human pilot, we might mention one other of great importance—the protection of the pilot during a crash. There are two lines of attack on this problem: first, the structural design and arrangement of the airplane to minimize impact effects on the pilot; second, the use of the lap belt and shoulder harness to provide adequate restraint and support of the body against the effects of violent linear deceleration.

The system comprising seat, lap belt, and shoulder harness has, we believe, capabilities of protecting the pilot considerably greater than those developed to date. Those of you who have had occasion to struggle with Navy requirements may have puzzled over the apparent paradox that places a desired limit of about 4*g* on linear acceleration during catapulting while calling for a 40*g* design ultimate horizontal anchorage of the pilot's seat.

As to the former, the linear acceleration during catapulting must be kept low in order that the pilot may retain adequate use of his hands and feet to control the airplane during take-off.

On the other hand, the 40*g* seat strength requirement is utilized to provide only a condition of passive restraint of the pilot's body and reflects the results of two sets of interesting studies: first, actual tests by the Bureau of Medicine and Surgery in which volunteer human subjects sustained, without injury, lap belt and shoulder harness impacts of the order of 20*g;* second, crash injury investigations by other agencies which show that humans have tolerated comparable forces in excess of 40*g*.

Further to explore this important field, the Navy is installing load recording dynamometers in the seat harnesses of some 800 fighters, with the object of securing actual measurements of loads sustained in the event of a crash. These data will serve as a basis for further study and development of this valuable aid to pilot safety.

So much for a brief outline of the problem of establishing an environment in the airplane suitable to the needs and reaction times of the human pilot—with the twin objectives of providing the best possible pilot for the airplane and the best possible airplane for the pilot.

Conclusion

Thus far we have outlined the role of sea-air power in the overall program of national defense and suggested the vital contribution the Navy can make through carrier-based aviation.

No one emphasizes more strongly than the Navy, however, that national security cannot be provided by a single weapon. On the contrary—to return to our earlier theme—in the unhappy event that war cannot be prevented, our expectation of victory is built on unification, but unification in the broadest national sense, which will give full understanding and recognition to the integrated responsibilities of all aspects of air, sea, and land and which will demand and utilize the utmost in effective cooperation not only from the military but from every element in our national life. This will require expert and knowledgeable exploitation of every worth-while and effective agency of offense and defense in our national arsenal.

These of us who understand the contributions of aeronautical science and industry which have made carrier-based aviation possible see a weapon of extraordinary potentialities—a weapon of two-fold uniqueness, unique in technical capabilities and unique because it is an extra asset possessed by the United States alone and by no other nation in the world. That weapon is mobile air power—a vitally important member of our national defense team.

Mr. John Nicholas Brown, the Assistant Secretary of the Navy for Air, phrases it this way:

> "...There is no competition between the Air Force and the air power of the Navy. They are complementary, and the functions of each do not duplicate those of the other. Together, under unified command, they provide an assortment of tools which is essential. Each has functions which now and tomorrow only it can perform. Both require your support."

Announcing a New Journal Department . . . Readers' Forum

It has been suggested by several members of the I.A.S. Editorial Committee that the *Journal* open a special department to fill the need for the more immediate communication of essential results of research in the greatly expanded and accelerated fields of the aeronautical sciences. Therefore, it has been decided to establish a new department, the "Readers' Forum," which will include letters to the editor for the quick publication of (1) brief reports of important findings in aeronautical sciences and (2) discussions of papers published in the *Journal*.

Specifications for Submission of Material

(1) All letters should be accompanied by a suggested short title, giving some indication to the reader of the subject under discussion.
(2) These letters should not exceed 800 words in length.
(3) Publication will be completed 6 to 8 weeks after receipt of the material.
(4) The Editorial Committee will not hold itself responsible for the opinions expressed by the correspondents, and no proofs will be sent to the authors.
(5) All letters should be double-spaced.

It is hoped that the new department may be started with the January, 1949, issue of the *Journal*. Contributions should be sent to:

Editor, Journal of the Aeronautical Sciences
2 East 64th Street
New York 21, New York

The Application of Metallurgy to Aircraft Design*

LEO SCHAPIRO†

Douglas Aircraft Company, Inc.

Introduction

THIRTY YEARS AGO, speaking before the newly formed American Steel Treaters Society—the forerunner of the present American Society for Metals—Charles Scott, a prominent commercial heat treater, said: "It is the duty of this (new) Society to show that the (heat) treatment of steel is not a mystery but an art." The techniques of metal manufacture and of heat-treatment, both encompassed in the word metallurgy, have progressed considerably in the intervening 30 years, until, today, hushed voices speak on occasion of the *science* of metallurgy.

When metallurgical science develops a material that is an improvement over a previously used one, either in respect to strength or corrosion resistance or formability, or machinability or weldability, designers incorporate the new material into air-borne vehicles either as modifications of models already constructed and in use or of models in the course of construction or of models still on the drawing boards. Thus, another milestone of metallurgical contributions is passed. Some interesting examples of such contributions that have already been made and some contributions that are currently being developed for future adoption into aircraft design will be discussed. These discussions will be made from the point of view of present-day metallurgical science.

Examples from Yesterday

Among aircraft designers, the aluminum alloy 75 S must be listed as the foremost accepted metallurgical contribution of the last decade. With its greater load-carrying capacity than the previously used 24 S alloy, the 75 S alloy has contributed a share in the large forward step in aircraft speed, the foremost factor by which air progress is measured. It must be remembered that 75 S alloy is not a modification of the previously existing 24 S alloy. The older alloy is a copper bearing aluminum; the new alloy is a zinc and magnesium bearing alloy. To produce a new, stronger alloy is not a simple problem in formulation. Metallurgical science is not yet at the stage that permits prediction of properties from basic data. It may be interesting to review the basic data applicable to predicting the properties of a new aluminum alloy.

The mechanism of hardening aluminum alloys is commonly termed "age hardening" or "precipitation hardening." The latter term is to be preferred, since it more pictorially describes the process that takes place.

Precipitation-Hardening Requirements

The precipitation-hardening mechanism requires the fulfillment of four conditions concerning the added metal and the base metal. The added metal must be soluble in the base metal not only in the liquid phase of metal manufacture but also in the solid phase of metal usage. As with liquid solubility, solid solubility connotes a complete absence of any—even minute—separation of one distinct metal from the other. The condition of solid solubility necessary to the precipitation-hardening mechanism is that "a limited solubility" of the added metal in the base metal shall take place. Limited solid solubility means that any quantity of the added metal is not completely soluble in the base metal but that, when more than 5 or 10 or 15 per cent, as the case may be, of the added metal is dissolved in the base metal while in the liquid state, in the solid state a precipitated phase will be discernible by microscopic and other means of detection, and this precipitated phase will be a chemical compound of the added and the base metal. Limited solubility is the first condition for precipitation hardening.

The second necessary condition for precipitation hardening is that the magnitude of limited solubility of the added metal in the base metal shall vary with change of temperature of the solid and, specifically, that the variation shall be a further limitation or reduction of solubility with decrease in temperature. The third necessary condition is that the difference in magnitude of limited solubility between some elevated temperature and some lower temperature shall produce a sufficient quantity of precipitated intermetallic compound to harden the entire body. Hardening takes place, with sufficient quantity of precipitate, if the precipitation can be suspended by rapid cooling between the upper and lower temperatures of limited solubility variation, thereby producing a supersaturated solid solution at the lower temperature. From this supersaturated solid solution, precipitation of submicroscopic sized

* The author desires to express his appreciation to the following companies for permission to discuss their data: to Northrop Aircraft, for Black Widow Spar Cap data; to Crucible Steel Company, for Hytuf data.

† Metallurgical Engineer, Testing Division.

TABLE 1

Metallic Elements of Periodic Table with Their Atomic Diameters (Data from Reference 1).

	I		II		III		IV		V		VI		VII		VIII		
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A		
2	3 Li 1 (2)		4 Be 2 (2)			5 B 3 (2)											
3	11 Na 1 (2-8)		12 Mg 2 (2-8)		13 Al 3 (2-8)			14 Si 4 (2-8)									
4	19 K 1 (2-8-8)		20 Ca 2 (2-8-8)		21 Sc 2 (2-8-9)		22 Ti 2 (2-8-10)		23 Va 2 (2-8-11)		24 Cr 1 (2-8-12)		25 Mn 2 (2-8-13)		26 Fe 2 (2-8-14)	27 Co 2 (2-8-15)	28 Ni 2 (2-8-16)
		29 Cu 1 (2-8-18)		30 Zn 2 (2-8-18)		31 Ga 3 (2-8-18)		32 Ge 4 (2-8-18)		33 As 5 (2-8-18)		34 Se 6 (2-8-18)					
5	37 Rb 1 (8)		38 Sr 2 (8)		39 Y 2 (8)		40 Zr 2 (8)		41 Cb 1 (8)		42 Mo 1 (8)						
		47 Ag 1 (8)		48 Cd 2 (8)		49 In 3 (8)		50 Sn 4 (8)		51 Sb 5 (8)		52 Te 6 (8)					
6	55 Cs 1 (8)		56 Ba 2 (8)				72 Hf 2 (8)		73 Ta 2 (8)		74 W 2 (8)						78 Pt 2 (8)
		79 Au 1 (8)		80 Hg 2 (8)		81 Tl 3 (8)		82 Pb 4 (8)		83 Bi 5 (8)							

TABLE 2

Metallic Elements of Periodic Table with Their Number of Valence Electrons. Inner Shell Electron Distribution in Parentheses (Data from reference 2).

	I		II		III		IV		V		VI		VII		VIII		
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A		
2	3 Li 313		4 Be 225			5 B 2											
3	11 Na 383		12 Mg 320		13 Al 285			14 Si 233									
4	19 K 476		20 Ca 393		21 Sc 320 (327)		22 Ti 293		23 Va 271		24 Cr 257 (271)		25 Mn 275		26 Fe 252	27 Co 250	28 Ni 249
		29 Cu 2551		30 Zn 2748		31 Ga 2770		32 Ge 2788		33 As		34 Se					
5	37 Rb 502		38 Sr 429		39 Y 362		40 Zr 319		41 Cb 294		42 Mo 280						
		47 Ag 2883		48 Cd 3042		49 In 314		50 Sn 3164		51 Sb 3228		52 Te					
6	55 Cs 540		56 Ba 448				72 Hf 317		73 Ta 294		74 W 282						78 Pt 2769
		79 Au 2878		80 Hg 310		81 Tl 342		82 Pb 349		83 Bi 364							

TABLE 3

Metallic Elements of Periodic Table Which Adopt F.C.C. of B.C.C. of H.C.P. Structure (Data from reference 1).

	I		II		III		IV		V		VI		VII		VIII		
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A		
2	3 Li BCC		4 Be HCP														
3	11 Na BCC		12 Mg HCP		13 Al FCC												
4	19 K BCC		20 Ca FCC		21 Sc FCC		22 Ti HCP		23 Va BCC		24 Cr BCC		25 Mn BCC		26 Fe BCC	27 Co HCP	28 Ni FCC
		29 Cu FCC		30 Zn HCP													
5	37 Rb BCC		38 Sr FCC		39 Y HCP		40 Zr HCP		41 Cb BCC		42 Mo BCC				44 Ru HCP	45 Rh FCC	46 Pd FCC
		47 Ag FCC		48 Cd HCP													
6	55 Cs BCC		56 Ba BCC				72 Hf HCP		73 Ta BCC		74 W BCC		75 Re HCP		76 Os HCP	77 Ir FCC	78 Pt FCC
		79 Au FCC				81 Tl HCP		82 Pb FCC									

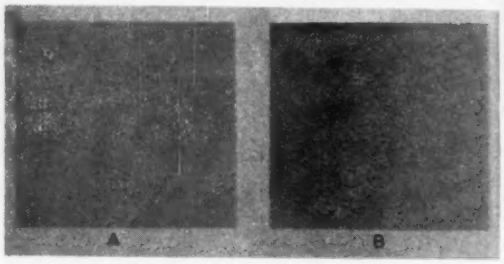


FIG. 1. Microstructure of a solid solution alloy (A) compared with a matrix containing a submicroscopic precipitated phase (B). Example is 61S aluminum alloy, etched with Keller's reagent.

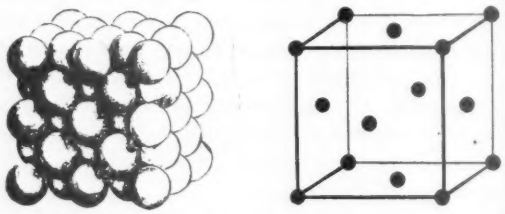


FIG. 2. Atomic packing in face centered cubic structure, "F.C.C." (from reference 2).

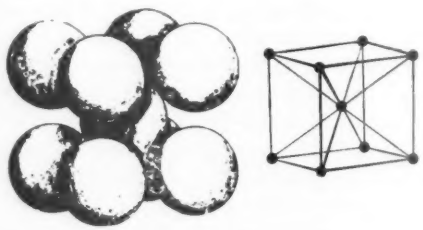


FIG. 3. Atomic packing in body centered cubic structure, "B.C.C." (from reference 2).

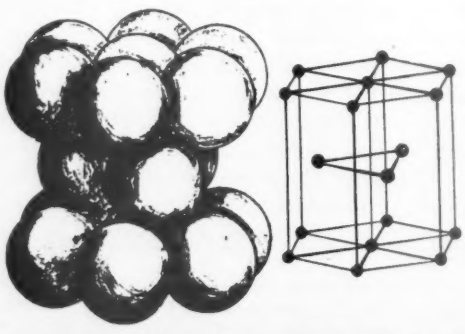


FIG. 4. Atomic packing in hexagonal close packed structure, "H.C.P." (from reference 2).

particles takes place at the lower temperature, and a hardness increase is produced by the submicroscopic particles resisting deformation of the matrix.

The difference in appearance between the absence and the presence of submicroscopic-sized particles is illustrated in Fig. 1. The clouded appearance of the polished and etched metal grains at "B" is in sharp contrast to the clear appearance of the grains at "A." The fourth requisite is that the rate of diffusion of the precipitating compound shall be slow enough to permit suppression of precipitation by rapid cooling but that the diffusion rate shall not be so slow that precipitation from the supersaturated solid solution cannot be forced to occur.

Before returning to the comparison of the zinc-magnesium alloy 75 S with the copper alloy 24 S in terms of the precipitation-hardening mechanism herein described, we should like to present some of the modern fundamental concepts of metals in order to point out to what extent the greater strength of the 75 S alloy was scientifically predictable.

Atomic Structure

In common with other known elements, the vapor phase of metals comprises atoms, each of which has a characteristic mass and positively charged nucleus around which a characteristic number of negatively charged electrons are in continual motion in definite, characteristic patterns. The total volume occupied by a single atom is not specifically spherical in shape, but it has been measured by chemical and physical testing techniques, coupled with mathematical calculations, and is generally expressed as the diameter of a spherical space. A listing of the atomic diameters of metals is presented in Table 1.

Note that, in passing vertically down a column to metals of more and more electron shells, the atomic diameter increases. Note also that, in passing horizontally to the right to metals filling an outer electron shell, the atomic diameter decreases, even though the nuclear mass and the number of electrons are increasing. While these size values have been determined for the vapor phase of the metals, it is believed that the characteristic atomic diameter is not altered by added or removed energy but remains constant from absolute zero to all elevated temperatures. Only atomic fission alters the characteristic atom diameter, and in that case the alteration is destruction. Added energy, as by heating, increases the amplitude of vibration of the atom.

Within an atom, the electrons are in motion in characteristic patterns such that only a characteristic number move to the peripheral region of the atom while others restrict their motion to specific inner layers. Those electrons, which do move into or within the outermost atomic region, regulate specific chemical activities of the atom, and these electrons are termed the valence electrons. The characteristic number of valence electrons for the metals are itemized in Table 2, together with the designations of the inner electron configurations. The control of properties of metals as regulated by the valence electrons probably applies to the liquid state (the data were determined from gases) but may not apply in its entirety to the lower temperature solid state.

One additional fundamental property of metals will be discussed. This is the property of metal atoms in the solid state to associate together in regular and specific patterns. Three distinct patterns characterize almost all metals. These patterns are termed "face centered cubic (F.C.C.)," "body centered cubic (B.C.C.)," and "hexagonal close packed (H.C.P.)." The three patterns are pictorially represented in Figs. 2–4, inclusive, and the characteristic patterns of the metals that inherently adopt one of these patterns are presented in Table 3. Metals appearing in Tables 1 and 2 but not in Table 3 adopt crystal patterns other than the three here discussed. The number of such other metals is small and the other crystal patterns will not be discussed.

We may now review solid solubility in terms of the fundamental facts depicted in Tables 1, 2, and 3. Two metals will have unlimited solid solubility in each other if their crystal patterns are similar, their atomic radii are nearly similar, and their number of valence electrons are equal. Differences in crystal pattern, in number of valence electrons, or in atomic radii limit the solid solubility, and large differences do not permit any solubility. What is the situation regarding the aluminum alloy 24 S in the light of the foregoing discussion and could the desirable properties of the 75 S alloy have been predicted from the fundamental facts described?

Comparing copper and aluminum on the basis of the data in Tables 1, 2, and 3, we note that both are face centered cubic metals but that their valence electrons are different by 2 (Al-3; Cu-1) and their atomic diameters differ by approximately 10 per cent (Al-2.85; Cu-2.551). A limited solubility of copper in aluminum (and also of aluminum in copper) is thus indicated and the first condition for precipitation hardening is present. Note, now, that the fundamental science concerning metals does not yet offer any clues to the other conditions necessary for precipitation hardening. Laboratory testing is necessary to establish that the limited solubility of copper in aluminum does indeed decrease with decreasing temperature. It is convenient to record the solubility relationship in the form of a phase diagram. Fig. 5 is such a diagram. The curved line AB designates the decreasing limited solubility with decreasing temperature. The change in copper solubility from approximately 6 per cent at about 500°C. to practically zero at room temperature indicates that a sufficient volume of precipitating compound is available for hardening. Rapid cooling and strength testing are necessary to establish that diffusion rates in the copper aluminum alloy do not restrict the precipitation.

A similar comparison of zinc with aluminum and magnesium discloses that the three metals differ by

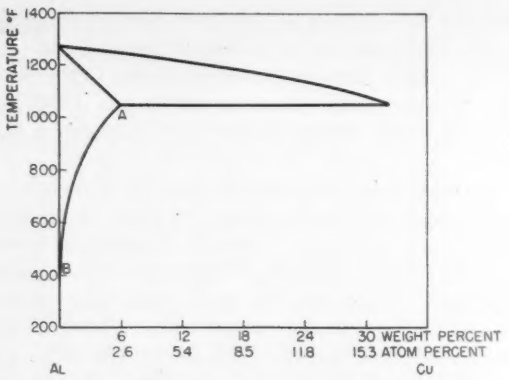


FIG. 5. Phase diagram of aluminum-rich Al-Cu system. Curved line AB designates decreasing solid solubility of copper in aluminum (with decreasing temperature) (from reference 4).

only one valence electron (Zn-2; Mg-2; Al-3), that zinc differs little from aluminum in atomic diameter with magnesium having a greater difference (Al-2.85; Zn-2.748; Mg-3.20), and that zinc and magnesium are both hexagonal close packed metals, different from face centered cubic aluminum. Thus, limited solubility of zinc in aluminum and of magnesium in aluminum is indicated, and the first step in producing a precipitation-hardening alloy is not difficult. Known phase diagrams for zinc-aluminum, magnesium-aluminum, and magnesium-zinc indicate that the limited solubility in each case does decrease with decreasing temperatures and, furthermore, that a sufficient mass of precipitating phase will be present. The metal manufacturer had to determine that diffusion rates did not obstruct the precipitation-hardening mechanism, and he had to measure the strength of the new, hardened alloy to learn that it was higher than the older 24 S alloy.

Single Crystal Properties

Fundamental science is not yet helping to predict strength because the science has not yet learned what is the fundamental strength of the pure metals. The subject of the linkage between metal atoms which resists an applied force is receiving studious attention in several quarters, but the answers are not yet forthcoming. The answers will no doubt relate to atomic diameter, number of valence electrons, and type of crystal pattern. Tests with pure single crystals of several metals do indicate interesting values for the elastic modulus. In Table 4 is presented a comparison of some pure metal moduli with the values for the commercial metals and with atomic diameters. In this small list, the metals of smaller atomic diameter—tighter metals, if we may thus refer to the electrons being held closely to the nucleus—strain less with increasing tension load (higher elastic modulus). It should not be inferred that this tentative deduction will apply to all metals. These examples are listed only to illustrate some degree of complexity in the fundamental factors.

Basic scientific knowledge offers no aid in predicting stress-corrosion tendencies. This must be separately studied before marketing the new metal. As 75 S alloy becomes applied in ever larger cross sections, our knowledge of the reduction in speed of cooling at the center of large cross sections is being expanded to reveal that the diffusion rate of the precipitation-hardening phase is not sufficiently adequate to prevent precipitation at the cooling rates existing at the center of large cross sections. Lower hardness at such centers is the result.

Steel Hardening

The mechanism of hardening steels is not much different from that which operates for aluminum alloys. The fundamental similarity between the two families of metals is that hardening results from a precipitation of submicroscopic sized particles. The two essential differences are: (1) While with aluminum alloys the precipitated particles are compounds of the alloying elements with the base metal, with steels the precipitated particles are not compounds of the alloying elements with the base metal but are always compounds of carbon. (2) While with aluminum alloys the precipitation does not take place in the quenching phase of solution treating, with steels the precipitation does take place in the quenching phase. The fundamental reason for the latter condition is: (1) the difference in solubility of carbon (or carbide) in face centered cubic iron and in body centered cubic iron, and (2) the change or transformation that iron undergoes from a face centered cubic structure stable at elevated temperatures to a body centered cubic structure stable at lower temperatures. Steel hardening is often called transformation hardening to indicate the last described phenomenon, but it should be remembered that hardening actually occurs because of a precipitation. As with aluminum alloys, softening of the hardened condition will result when the submicroscopic sized precipitate is agglomerated by heating.

In steels, the principal usefulness of the alloying elements is their effect on the transformation from face

TABLE 4

Elastic Modulus (Uni-Axial Tension) of Some Common Elements. Modulus of Pure Single Crystals Differ from the Commercial Metals. Single Crystal Moduli May Be Function of Atomic Diameter (Data from reference 3).

METAL	COMMERCIAL METAL	PURE SINGLE CRYSTAL	ATOMIC DIAMETER OF METAL FOR COMPARISON
Fe	30×10^6 PSI	19.03×10^6 PSI	2.52 ANGSTROM UNITS
Cu	16	9.67	2.551
Al	10	9.12	2.85
Mg	6.25	6.46	3.20
Ag	10.3	6.21	2.883
Au	11.3	6.18	2.878
Pb	2.56	1.55	3.49

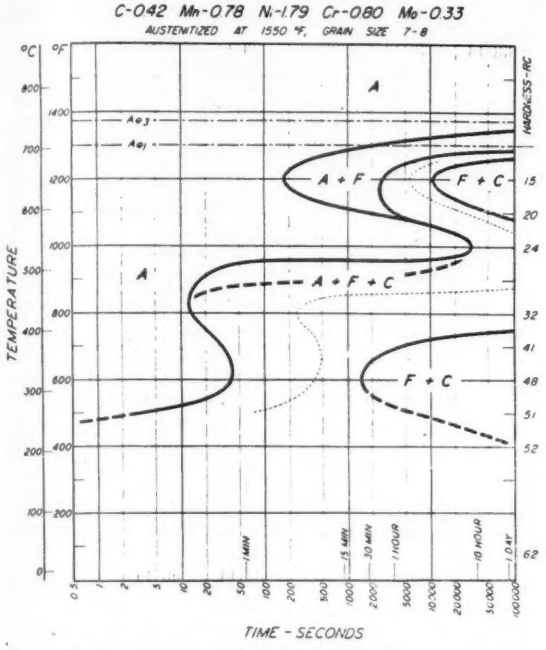


FIG. 6. Time-temperature-transformation diagram for SAE 4340 steel (from reference 5).

centered cubic iron to body centered cubic iron. Alloying elements that suppress this transformation to lower temperatures enable maximum hardening in greater thicknesses or larger cross sections. The transformation suppressing effect of a particular steel composition is illustrated in Fig. 6 for SAE 4340 steel, an extremely desirable steel for aircraft use because of its high strength and deep hardening capabilities. The position of the knee of the curve of Fig. 6 indicates the hardening capacity of this alloy, but it also indicates the greater cracking tendency of this alloy in welding. A local area, air cooled from welding heat, becomes a locally hard, brittle area susceptible to cracking from thermal and mechanical stresses induced in the cooling of a locally welded part. It seems proper, therefore, to record, as a metallurgical contribution to aircraft design, the application of flash welded 4340 steel to the Black Widow Wing Spar Caps. A 4.1 sq.in. cross-sectional area tube originally designed to carry a wing load of approximately 625,000 lbs. was finally required, because of design modifications, to carry a load of 750,000 lbs. Space limitations did not permit increasing the size of the 4130 tube initially designed for the part. Higher strength 4340 steel was the logical choice replacement material if weld cracking were prevented. The simple solution, to prevent localized quenching from welding heat by postheating the entire welded assembly to cherry red and air cooling, permitted the production of these spars to final design requirements. In this case not a new material but a metallurgically designed heat-treatment contributed to the final design. Before leaving the subject of steel hardening, it is proper to point out that alloying elements do have some hardening effect per se other than their effect on suppressing the atomic pattern transformation. The "solution hardening" effect of steel alloying elements in carbon-free pure iron is illustrated in Fig. 7. Note that the strengthening effect of these solution elements occupying atomic spacings in the iron lattice is greater with the elements Be-Cu-Si-Ti, which are of different atomic patterns than iron (and generally also of smaller atomic diameters).

New High-Strength Steels

While all steels with which we have been familiar in the past are of the transformation hardening type as described, a new precipitation-hardening steel is finding its place in aircraft design. Like precipitation-hardened aluminum alloys, the new steel is hardened by an aging treatment. This type of steel is of the corrosion-resistant type and is age-hardenable to 200,000 to 240,000 lbs. per sq.in. ultimate strength. In its solution-treated condition, its strength of approximately 140,000 lbs. per sq.in. places it in the class of half hard 18-8 with, however, more ductility than is associated with the latter material. Reasonable forming operations can be accomplished with the solution-treated temper, and aging at temperatures in the range of 850°–950°F. produces the high strength properties of 200,000–240,000 lbs. per sq.in. Three variations of this precipitation hardenable stainless steel are commercially available* for the strength range stated. The weight savings possible with this high-strength material makes its application desirable even in parts not requiring the corrosion resisting property of the material. One application in ballistics (flak plate) has been made with this steel as has an application in a movable bomb-bay door. Applications to nonpiloted air-borne vehicles are in the offing, where high strength, together with corrosion resistance, will find usefulness.

* Stainless, W., U.S. Steel Corporation. 17-7 PH, Armco. Rezistal 3311, Crucible.

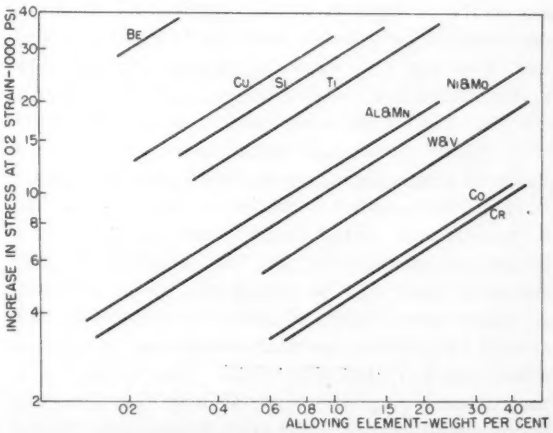


FIG. 7. Solution hardening effect of metals in carbon-free iron (from reference 6).

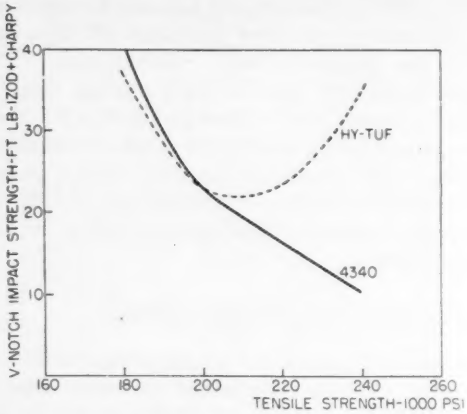


FIG. 8. Notch toughness of Hy-Tuf compared with SAE 4340 steel (Hy-Tuf data courtesy Crucible Steel Company).

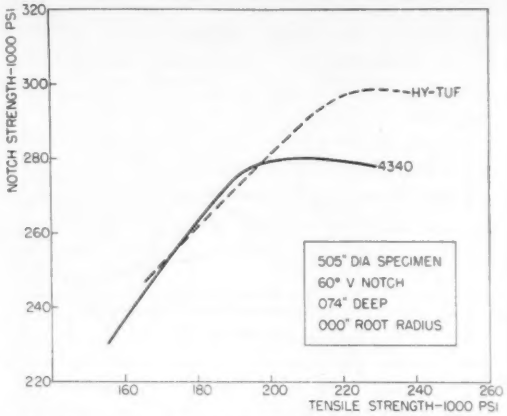


FIG. 9. Notch strength of Hy-Tuf compared with SAE 4340 steel (courtesy Crucible Steel Company).

While low ductility is commonly associated with high strength above 200,000 lbs. per sq.in., a new development not yet being applied to aircraft design is a transformation hardening steel at approximately 240,000 lbs. per sq.in. with ductility worthy of consideration.* Differing from 4340 steel in nominal chemical composition as shown below, this new steel has markedly different properties at high-strength levels. Of particular interest is the shock resistance as measured by a notch impact test, Fig. 8, and the notch sensitivity as measured by a notch tensile test, Fig. 9. The full measure of this steel has not yet been taken, and we may look forward to modifications of the composition to overcome undesirable properties that further study may reveal. Many applications in tomorrow's designs seem certain with this new material.

	C	Mn	Si	Ni	Cr	Mo
4340	0.40	0.70	0.30	1.80	0.75	0.25
Hytuf	0.25	1.30	1.50	1.80	..	0.40

HIGH-TEMPERATURE APPLICATIONS

Some discussion of atomic structure was made in relation to the strength of metals, particularly to clarify some reasons for science's inability to predict properties. The use of metals at elevated temperatures further obstructs the understanding of the basic fundamentals. Since time, under load, decreases the stability of metals at elevated temperatures, a time rate of change of properties is now an added parameter in the study of fundamentals. Studies to date indicate that the properties of atomic patterns will not alone reveal the desired answers but that the properties of grain boundaries must now be considered. Grain boundaries, where several layers of atoms are not strictly held in one of the patterns described, seem to act as a viscous rather than a crystalline material. The elevated temperature creep properties of metals may be governed by the viscous properties of the grain boundaries. Such a relationship is indicated in Table 5 for three metals studied.

* Hytuf, Crucible.

TABLE 5

Activation Energies Indicating Relationship Between Creep Properties of Metals and Grain Boundary Properties (Data from Reference 7).

METAL	GRAIN BOUNDARY SLIP	CREEP
ALUMINUM	34,500 CAL /MOLE	37,000 CAL /MOLE
α-BRASS	41,000	42,000
α-IRON	85,000	90,000

NEW ART OF METAL MANUFACTURE

A present-day discussion of metallurgy and aircraft design would not be complete without some mention of the newest development in the art of metal manufacture. Designed for high melting point metals for which no normal melting containers are known, this new technique melts by means of the common electric arc, but melting takes place within a water-cooled copper chamber that becomes the melting chamber and the solidifying mold. This process, encased in a vacuum to protect readily oxidizable metals, is now producing the interesting metal molybdenum and will, in the next decade, produce the interesting metal titanium. These two metals, ductile in their pure form, are both interesting to aircraft designers because their properties are so different from the construction materials available to date. With its elastic modulus approximating 50×10^6, its relatively good formability, and the outlook for strengths above 100,000 lbs. per sq.in. by means of alloy additions, the metal molybdenum will receive considerable attention from aircraft designers in the next decade.

Titanium merits attention on the strength of its being the fourth most plentiful metal and also for its elastic modulus and density intermediate between aluminum and steel. Alloy developments with this

metal may likewise be expected to produce interesting high strengths that will merit the ardent interest of aircraft designers.

Conclusion

Some examples were discussed of metallurgical developments that found their way into aircraft design in the past and present and which show promise of future application.

References

[1] Hume-Rothery, W., *The Structure of Metals and Alloys*, Tables III–IX, pp. 47–55, The Institute of Metals, 1945.

[2] Hume-Rothery, W., *Atomic Theory for Students of Metallurgy*, Table II, pp. 54–56, The Institute of Metals, 1947.

[3] Seitz, F., *The Physics of Metals*, Table VII, p. 69; McGraw-Hill Book Company, Inc., New York, 1943.

[4] Dowdell, et al., *General Metallography*, Appendix p. 275; John Wiley & Sons, Inc., New York, 1943.

[4] *Atlas of Isothermal Transformation Diagrams*, p. 64, United States Steel Corporation, 1943.

[4] Gensamer, M., *Strength and Ductility*, Metal Progress, Vol. 49, No. 4, pp. 731–734.

[4] T'ing-Sui Kĕ, *On the Structure of Grain Boundaries in Metals*, Physical Review, Vol. 73, pp. 267–268, 1948. Also Chemical Abstracts, Vol. 42, p. 2216, 1948.

[4] Gee, et al., *Metallic Titanium is Light, Strong, Durable and Corrosion Resistant*, Materials and Methods, Vol. 27, No. 1, pp. 75–78.

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I.A.S. Briefs

Summaries of current papers accepted for publication or presentation at I.A.S. Meetings

Wind-Tunnel Testing Problems in Superaerodynamics

By

Hsue-Shen Tsien

Massachusetts Institute of Technology

The problems in the experimentation of rarefied gas are discussed. First the extremely large viscous effects in a wind-tunnel nozzle is shown. Then the difficulties of flow measurement are surveyed, pointing out particularly the unconventional behavior of the Pitot tube in rarefied gas. The performance of a hot-wire anemometer is then studied in some detail to show its feasibility. Finally, the rules for achieving complete flow similarity of rarefied gas flow are formulated.

The Theoretical Induced Deflection Angle in Cascades Having Wall Boundary Layers

By

George F. Hausmann

United Aircraft Corporation

A theoretical analysis is presented which employs a lifting-line theory assuming incompressible, nonviscous flow to determine the induced deflection angle in two-dimensional cascades having wall boundary layers. Two correction factors are derived for the deflection angle of the idealized infinite cascade: one that accounts for the induced deflection due to the trailing vortex system in the wall boundary layer, and the other that accounts for the decrease in total circulation of the bound vortex system.

Plots are included which show the effect of blade length, boundary-layer thickness, and the number of blades in cascade on the deflection angle of several typical cascade configurations.

Vorticity in the Supersonic Flow About Yawing Cones

By

Mark M. Lotkin

Ballistic Research Laboratories

A comparison is made between Stone's and Sauer's methods of calculation of the supersonic flow about a slightly yawing cone. It is shown that the neglect of vorticity, while having only a small effect on the ratio of shock yaw to cone yaw, may lead to erroneous values of the normal force coefficient.

Please do not order Preprints of these papers at this time.

See pages 38 and 39 for Preprints that are immediately available.

Surface-Pressure Gradient and Shock-Front Curvature at the Edge of a Plane Ogive with Attached Shock Front

By

M. M. Munk and R. C. Prim

Naval Ordnance Laboratory

The flow of air at high Mach Numbers past a sufficiently sharp plane ogive is characterized by the presence of a curved shock front attached to the edge of the ogive. This paper presents and carries out a simple method for computing the exact surface-pressure gradient and shock-front curvature at the edge of the ogive.

A comparison is made between the exact edge-pressure gradient and that given by two approximate methods of computing the pressure distribution along an ogive.

The numerical results, presented graphically, cover all ogives with attached shock fronts for Mach Numbers up to 13.

An Investigation of the Detached Shock in Front of a Body of Revolution

By

John Dugundji

Grumman Aircraft Engineering Corporation

Some theoretical investigations are made into the nature of the flow behind the detached shock formed in front of a body of revolution. The predicted values of the product of the curvature of the shock, and distance of the shock in front of the body, agree reasonably well with the experimental values of Charters and those of Ladenburg, Van Voorhis, and Winkler.

Spectrum of Locally Isotropic Turbulence

By

Leslie S. G. Kovasznay

The Johns Hopkins University

The concept of locally isotropic turbulence is used in Kolmogoroff's sense. Kolmogoroff's second similarity hy-

pothesis is not used, but other hypotheses are suggested for the similarity of energy transfer in the energy spectrum of turbulence. The spectrum thus obtained is identical with the $-5/3$ power law in the nonviscous range but falls off rapidly in the viscous high-frequency end. The correlation coefficients agree with Kolmogoroff's predictions for both small r and for large r and give explicit results in the intermediate range. The only free constant in the present theory is R_0, a certain Reynolds Number that corresponds to the smallest eddies. Extensive comparison with available energy spectrum and correlation measurements has been made.

Transonic Separation

By

Vernon Outman and Arthur A. Lambert

McDonnell Aircraft Corporation

The problem of avoiding airflow separation and air-frame shaking and control surface buffeting at transonic flight speeds is discussed. A design parameter, identified as the angle between the aft surface of a body and the line of flight, is proposed as a useful tool for avoiding these difficulties and is correlated with flight and wind-tunnel test data. The correlation showed that for preliminary design purposes, the proposed parameter represents a satisfactory index of the Mach Number at which separation phenomena will occur on bodies and lifting surfaces. For wing-body junctures and tail intersections it is suggested that separation Mach Numbers be considered greater than the critical Mach Numbers by 0.10.

Fracturing Characteristics of Aluminum-Alloy Plate

By

L. J. Klinger and G. Sachs

Case Institute of Technology

Commercial hot-rolled $1^1/_2$-in. 24ST aluminum plate exhibited large variations in fracture stress and reduction in area for different orientations of the test specimens. These variations were attributed to mechanical anisotropy in the plate. Measurement of the angles at which the specimens fractured indicated the presence of a plane of weakness, but no fracture function could be found to correlate this with the fracture stresses and ductilities.

The Behavior of Thin Cylindrical Shells After Buckling Under Axial Compression

By

Herman F. Michielsen

Fokker Aircraft Factories, Amsterdam

The fundamental investigations of von Kármán and Tsien on the buckling of their cylindrical shells under axial compression are continued. The energy expression is simplified and minimized with respect to the axial and circumferential wave-length parameters. Solution of the equations obtained yields curves of the reduced average stress and of the wave dimensions plotted against the reduced average strain. They illustrate the behavior of the cylinder during the buckling process. The minimum buckling stress is found to be 0.195 $E(t/R)$.

I.A.S. National Meeting Schedule

Wright Brothers Lecture—U.S. Chamber of Commerce Auditorium, Washington, D.C.—December 17, 1948

Seventeenth Annual Meeting—Hotel Astor, New York, N.Y.—January 24-27, 1949

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee at least 3 months prior to the meeting.

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152	Principles of Structural Design for Minimum Weight—F. R. Shanley, Consulting Engineer, Lecturer, University of California (L.A.)
153	The Application of Metallurgy to Aircraft Design—Leo Schapiro, Metallurgical Engineer, Testing Division, Douglas Aircraft Company, Inc.
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160	Design and Operation of a 12" Supersonic Wind Tunnel—Allen E Puckett, California Institute of Technology
161	Recent NACA Research on High Length-Beam Ratio Hulls—Arthur W. Carter, Hydrodynamics Division, Langley Memorial Aeronautical Laboratory, National Advisory Committee for Aeronautics
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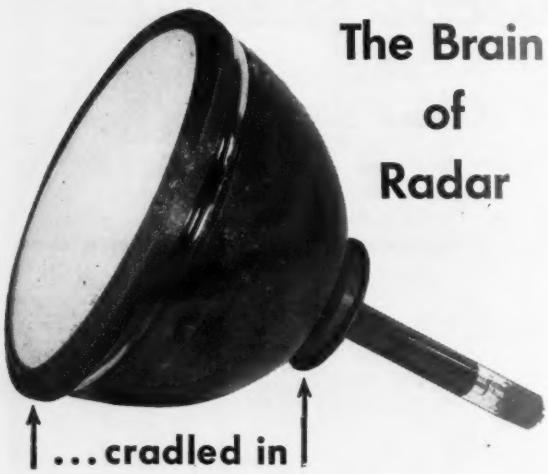

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Aerodynamics (2)

AERODYNAMIC LOADS

Aerodynamic Properties of Slender Wing-Body Combinations at Subsonic, Transonic, and Supersonic Speeds. John R. Spreiter. *U.S., N.A.C.A., Technical Note No. 1662,* July, 1948. 33 pp., figs. 20 references.

A method based on assumptions similar to those of Munk's airship theory and R. T. Jones' low-aspect-ratio pointed-wing theory has been developed, and expressions have been determined for the load distribution, lift, and pitching moment of inclined slender wing-body configurations having flat-plate wings and circular fuselage sections. The results are applicable at subsonic and transonic speeds, and at supersonic speeds, provided the entire wing-body combination lies near the center of the Mach cone. The aerodynamic characteristics of a moderate-aspect-ratio pointed wing at sonic speed may be predicted in a manner mathematically equivalent to that used in the study of a low-aspect-ratio wing.

Gust-Tunnel Tests to Determine Influence of Airfoil Section Characteristics on Gust-Load Factors. Harold B. Pierce and Mitchell Trauring. *U.S., N.A.C.A., Technical Note No. 1632,* July, 1948. 12 pp., illus., figs. 7 references.

The results indicate that low-drag and conventional airfoil sections show the same slopes of the lift curves in gusts with gradient distances up to twelve chords. Until further information is obtained, it is suggested that the section slope of the lift curve of all airfoils be assumed to be approximately 6.0 per rad. and that the lift-curve slope for finite wings be obtained by simple corrections for aspect ratio.

BOUNDARY LAYER

An Exact Solution of the Boundary-Layer Equations Under Particular Conditions of Porous Surface Suction. B. Thwaites. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2241,* May, 1946. 6 pp., figs. 4 references. British Information Services, New York. $0.45.

An exact solution of the boundary-layer equations of motion when there is a continuous suction velocity proportional to $X^{-1/2}$ at the boundary normal to the flow, and a constant velocity outside the boundary layer. A differential analyzer was used to obtain solutions of the differential equations in this extension of the well-known Blasius solution.

On Certain Types of Boundary-Layer Flow with Continuous Surface Suction. B. Thwaites. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2243,* July, 1946. 6 pp. 3 references. British Information Services, New York. $0.45.

A proof that the boundary-layer velocity profile near the front of a flat plate in a uniform stream with constant, continuous, surface suction through the plate tends to the well-known Blasius profile as the front end of the plate is approached. It is also shown that, when "similar" velocity profiles are assumed in the solution of the boundary-layer equations of motion, "similar" profiles can be obtained in boundary-layer flow in only three general cases of stream velocity distributions, in each of which there is associated a particular distribution of surface suction giving also similar profiles.

Wind-Tunnel Investigation of Boundary-Layer Control by Suction on NACA 65_5-424 Airfoil with Double Slotted Flap. Stanley F. Racisz and John H. Quinn, Jr. *U.S., N.A.C.A., Technical Note No. 1631,* June, 1948. 30 pp., diagrs., figs. 7 references.

The airfoil was tested with a double slotted flap and with three arrangements of single boundary-layer-control suction slots. The maximum lift coefficient at $R = 6.0 \times 10^6$ was increased from 1.4 to 3.4 by deflecting the flap and from 1.4 to 4.2 by deflecting the flap and using boundary-layer control. Suction at $0.65c$ caused the ratio of the lift to the total drag of the airfoil with roughened leading edge to increase by more than 100 per cent and that of the smooth airfoil to increase by about 38 per cent.

Laminar Flow of a Slightly Viscous Incompressible Fluid That Issues from a Slit and Passes over a Flat Plate. Neal Tetervin. *U.S., N.A.C.A., Technical Note No., 1644,* June, 1948. 40 pp., figs. 14 references.

The investigation is made in a region far enough from the slit for the boundary-layer equations to be valid. The partial differential equation for the boundary layer is reduced to a third-order

nonlinear ordinary differential equation, which is integrated by numerical means for the required boundary conditions. The solution gives the velocities at points in the fluid and the surface friction at points on the plate.

An Experimental Investigation of an NACA 63_1-012 Airfoil Section with Leading-Edge Suction Slots. George B. McCullough and Donald E. Gault. *U.S., N.A.C.A., Technical Note No. 1683,* August, 1948. 41 pp., illus., figs. 6 references.

An NACA 63_1-012 airfoil section provided with 16 different suction slots near the leading edge was investigated to determine whether or not the laminar stall characteristics of the basic section might be delayed. Substantial increases in maximum lift were realized with increasing flow into the slot. The chordwise location and width of the slot were found to be important. Lift, drag, pitching-moment, pressure-distribution, and boundary-layer data are given for the best of the 16 slots investigated.

CONTROL SURFACES

Estimation of Effectiveness of Flap-Type Controls on Sweptback Wings. John G. Lowry and Leslie E. Schneiter. *U.S., N.A.C.A., Technical Note No. 1674,* August, 1948. 23 pp., figs. 12 references.

An analysis was made of the available experimental data on the low-speed lift, rolling, and pitching characteristics of flap-type controls on sweptback wings. The methods of calculating the control effectiveness parameters give satisfactory results for sweptback wings having sweep angles from 0° to 60°, aspect ratios from 2.50 to 6.00, and taper ratios from 0.4 to 1.0 for the range wherein lift has a linear variation with both wing angle of attack and flap deflection.

Characteristics of Thin Triangular Wings with Constant-Chord Partial-Span Control Surfaces at Supersonic Speeds. Warren A. Tucker and Robert L. Nelson. *U.S., N.A.C.A., Technical Note No. 1660,* July, 1948. 43 pp., figs. 6 references.

A theoretical analysis was made of characteristics of constant-chord partial-span control surfaces on thin triangular wings at supersonic speeds by use of methods based on linearized theory for supersonic flow. Two cases were treated: In one the flap extended outboard from center of wing, and in the other the flap extended inboard from wing tip. Expressions were found for lift coefficient, rolling-moment coefficient, and hinge-moment coefficient due to flap deflection, hinge-moment coefficient due to angle of attack, and pitching-moment coefficient due to flap lift. A few figures illustrate application of the equations.

Characteristics of Thin Triangular Wings with Constant-Chord Full-Span Control Surfaces at Supersonic Speeds. Warren A. Tucker. *U.S., N.A.C.A., Technical Note No. 1601,* July, 1948. 25 pp., figs. 7 references.

The linearized equation for supersonic flow was used in a theoretical analysis of the characteristics of constant-chord full-span control surfaces on thin triangular wings at supersonic speeds. Simple expressions for the lift effectiveness, pitching-moment coefficient, and hinge-moment coefficient due to angle of attack were obtained. High values were found for the lift effectiveness. For certain combinations of flap size, wing-apex angle, and Mach Number, the lift produced by a unit flap deflection was greater than the lift resulting from a unit angle of attack of the entire wing. These high values resulted from the low lift-curve slope of the wing rather than from any remarkable lift-producing capability of the flap. When the Mach lines were behind the leading edge, the ratio of lift effectiveness to hinge-moment coefficient due to control deflection showed the present arrangement to be slightly inferior to a two-dimensional wing-flap combination of the same flap-area to wing-area ratio. As the Mach lines moved ahead of the leading edge, however, the efficiency of the present arrangement reached and exceeded that of the two-dimensional combination.

High-Speed Wind-Tunnel Investigation of an NACA 65-210 Semispan Wing Equipped with Plug and Retractable Ailerons and a Full-Span Slotted Flap. Jack Fischel and Leslie E. Schneiter. *U.S., N.A.C.A., Technical Note No. 1663,* July, 1948. 81 pp., illus., figs. 18 references.

Results and discussion of a lateral-control investigation of plug and retractable ailerons on a thin, low-drag, semispan wing with a 25 per cent chord, full-span, slotted flap retracted or deflected. Data were obtained through a large angle-of-attack range and at Mach Numbers from 0.13 to 0.71. The characteristics of the plug and retractable ailerons are compared. A comparison is also made of the characteristics of the plug, retractable ailerons, and a sealed plain aileron previously tested on the same wing.

Lift, and Pitching Moment Measurements on an EC 1240 Tailplane Elevator at High Speeds with Elevator Gap Sealed. W. F. Hilton and A. E. Knowler. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2227,* September, 1944. 16 pp., diagrs., figs. 8 references. British Information Services, New York. $1.00.

High-speed wind-tunnel measurements of the lift, drag, and pitching moment for an airfoil with elevator showed that with gap sealed and with gap unsealed there was no serious loss of control until a Mach Number between 0.75 and 0.78 was reached. Controllability with gap unsealed was practically independent of the Mach Number between $M = 0.45$ and $M = 0.73$. With the gap sealed, the variation of control followed the Glauert formula from 0.4 to 0.7 Mach. Sealing the gap increased controllability by 40 per cent at $M = 0.4$ and 60 per cent at $M = 0.7$.

Low-Speed Wind-Tunnel Investigation of Various Plain-Spoiler Configurations for Lateral Control on a 42° Sweptback Wing. Leslie E. Schneiter and James M. Watson. *U.S., N.A.C.A., Technical Note No. 1646,* June, 1948. 29 pp., illus., diagrs., figs. 5 references.

A wing equipped with a group of spoiler segments located near the wing trailing edge, slightly inboard from the wing tip, and skewed with reference to the wing so as to be perpendicular to the free-stream airflow will exhibit fairly high values of rolling moment throughout the usable lift range.

Two-Dimensional Wind-Tunnel Investigation of an NACA 64-009 Airfoil Equipped with Two Types of Leading-Edge Flap. Felicien F. Fullmer, Jr. *U.S., N.A.C.A., Technical Note No. 1624,* June, 1948. 30 pp., illus., figs. 4 references.

The airfoil was equipped with leading-edge and trailing-edge high-lift devices. The high-lift devices consisted of two 10 per cent chord leading-edge flaps, one intended to slide forward along the upper surface and the other hinged at the center of the airfoil leading-edge radius. These flaps were tested individually and in combination with a trailing-edge split flap deflected 60°. The section lift and pitching-moment characteristics of the airfoil with the various high-lift devices are presented for a Reynolds Number of 6.0×10^6.

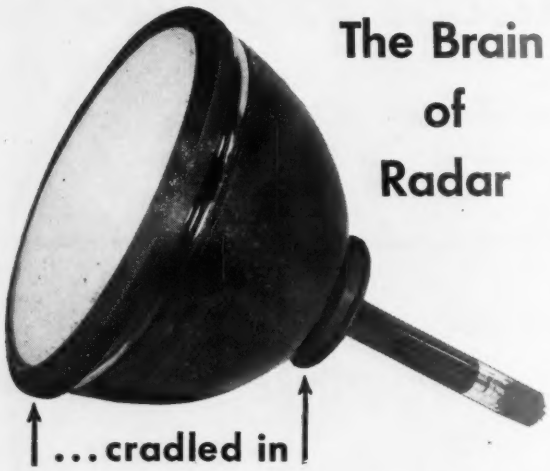
FLUID MECHANICS & AERODYNAMIC THEORY

Compressible Flows with Degenerate Hodographs. J. H. Giese. *U.S., Army Ordnance Department, Ballistic Research Laboratories, Aberdeen Proving Ground, Aberdeen, Md., Report No. 657,* February 15, 1948. 35 pp., figs. 18 references.

Nonlinearized, three-dimensional, steady, isentropic, compressible potential flows for which the maps of the physical space onto the hodograph space have less than three dimensions have been systematically studied by applying a degenerate Legendre transformation to the equation of the velocity potential function. This leads naturally to a synthesis of a number of familiar types of flows, such as (1) Prandtl-Meyer expansion around a corner and (2) Busemann's cylindrical and general conical flows, including Taylor-Maccoll flow. The most general flow with a one-dimensional map is a straightforward generalization of (1). Flows with two-dimensional maps must be either of types (2) or a modified ("skewed") conical type. The differential geometry of these flows has been thoroughly investigated to find analogues for many of the well-known properties of plane flow. As examples, all axisymmetric flows with degenerate hodographs have been considered, and boundary-value conditions and other properties of conical flow fields have been studied.

A Family of Streamline Bodies of Revolution Suitable for High-Speed or Low-Drag Requirements. A. D. Young and E. Young. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2204,* August, 1945. 15 pp., figs. 3 references. British Information Services, New York. $1.00.

Young and Owen's simplified theory for streamline bodies of revolution is used to calculate a family of basic shapes with a fineness ratio of 9.2. These shapes can be scaled up or down to any required fineness ratio to obtain smooth unpeaked velocity distributions that give minimum drag at speeds at which compressibility effects may be ignored or which delay shock waves and their attendant effects to as high a Mach Number as possible. The ranges of the velocity gradients and positions of maximum velocity are sufficiently wide so that one or more of the family will always be suitable for any particular purpose. The ordinates



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Aerodynamics (2)

AERODYNAMIC LOADS

Aerodynamic Properties of Slender Wing-Body Combinations at Subsonic, Transonic, and Supersonic Speeds. John R. Spreiter. *U.S., N.A.C.A., Technical Note No. 1662,* July, 1948. 33 pp., figs. 20 references.

A method based on assumptions similar to those of Munk's airship theory and R. T. Jones' low-aspect-ratio pointed-wing theory has been developed, and expressions have been determined for the load distribution, lift, and pitching moment of inclined slender wing-body configurations having flat-plate wings and circular fuselage sections. The results are applicable at subsonic and transonic speeds, and at supersonic speeds, provided the entire wing-body combination lies near the center of the Mach cone. The aerodynamic characteristics of a moderate-aspect-ratio pointed wing at sonic speed may be predicted in a manner mathematically equivalent to that used in the study of a low-aspect-ratio wing.

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The airfoil was tested with a double slotted flap and with three arrangements of single boundary-layer-control suction slots. The maximum lift coefficient at $R = 6.0 \times 10^6$ was increased from 1.4 to 3.4 by deflecting the flap and from 1.4 to 4.2 by deflecting the flap and using boundary-layer control. Suction at $0.65c$ caused the ratio of the lift to the total drag of the airfoil with roughened leading edge to increase by more than 100 per cent and that of the smooth airfoil to increase by about 38 per cent.

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CONTROL SURFACES

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Characteristics of Thin Triangular Wings with Constant-Chord Partial-Span Control Surfaces at Supersonic Speeds. Warren A. Tucker and Robert L. Nelson. *U.S., N.A.C.A., Technical Note No. 1660,* July, 1948. 43 pp., figs. 6 references.

A theoretical analysis was made of characteristics of constant-chord partial-span control surfaces on thin triangular wings at supersonic speeds by use of methods based on linearized theory for supersonic flow. Two cases were treated: In one the flap extended outboard from center of wing, and in the other the flap extended inboard from wing tip. Expressions were found for lift coefficient, rolling-moment coefficient, and hinge-moment coefficient due to flap deflection, hinge-moment coefficient due to angle of attack, and pitching-moment coefficient due to flap lift. A few figures illustrate application of the equations.

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The linearized equation for supersonic flow was used in a theoretical analysis of the characteristics of constant-chord full-span control surfaces on thin triangular wings at supersonic speeds. Simple expressions for the lift effectiveness, pitching-moment coefficient, and hinge-moment coefficient due to angle of attack were obtained. High values were found for the lift effectiveness. For certain combinations of flap size, wing-apex angle, and Mach Number, the lift produced by a unit flap deflection was greater than the lift resulting from a unit angle of attack of the entire wing. These high values resulted from the low lift-curve slope of the wing rather than from any remarkable lift-producing capability of the flap. When the Mach lines were behind the leading edge, the ratio of lift effectiveness to hinge-moment coefficient due to control deflection showed the present arrangement to be slightly inferior to a two-dimensional wing-flap combination of the same flap-area to wing-area ratio. As the Mach lines moved ahead of the leading edge, however, the efficiency of the present arrangement reached and exceeded that of the two-dimensional combination.

High-Speed Wind-Tunnel Investigation of an NACA 65-210 Semispan Wing Equipped with Plug and Retractable Ailerons and a Full-Span Slotted Flap. Jack Fischel and Leslie E. Schneiter. *U.S., N.A.C.A., Technical Note No. 1663,* July, 1948. 81 pp., illus., figs. 18 references.

Results and discussion of a lateral-control investigation of plug and retractable ailerons on a thin, low-drag, semispan wing with a 25 per cent chord, full-span, slotted flap retracted or deflected. Data were obtained through a large angle-of-attack range and at Mach Numbers from 0.13 to 0.71. The characteristics of the plug and retractable ailerons are compared. A comparison is also made of the characteristics of the plug, retractable ailerons, and a sealed plain aileron previously tested on the same wing.

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Young and Owen's simplified theory for streamline bodies of revolution is used to calculate a family of basic shapes with a fineness ratio of 9.2. These shapes can be scaled up or down to any required fineness ratio to obtain smooth unpeaked velocity distributions that give minimum drag at speeds at which compressibility effects may be ignored or which delay shock waves and their attendant effects to as high a Mach Number as possible. The ranges of the velocity gradients and positions of maximum velocity are sufficiently wide so that one or more of the family will always be suitable for any particular purpose. The ordinates

of the basic shapes are tabulated, and examples of velocity distributions at various angles of yaw illustrate the range of the low-drag properties.

Two-Dimensional Irrotational Transonic Flows of a Compressible Fluid. Yung-Huai Kuo. *U.S., N.A.C.A., Technical Note No. 1445*, June, 1948. 91 pp., figs. 10 references.

Methods developed by H. S. Tsien and the author are slightly modified and extended to include flows with circulation by considering the alteration of the singularities of the incompressible solution due to the presence of the hypergeometric functions in the analytic computation of the solution. It was found that for finite Mach Numbers the only case in which the nature of the singularity can remain unchanged is for a ratio of specific heats equal to −1. From a study of two particular flows it seems that the effect of geometry cannot be neglected and the conventional "pressure-correction" formulas are not valid, even in the subsonic region if the body is thick, especially if there is a supersonic region in the flow.

Method for Calculation of Pressure Distributions on Thin Conical Bodies of Arbitrary Cross Section in Supersonic Stream. Stephen H. Maslen. *U.S., N.A.C.A., Technical Note No. 1659*, July, 1948. 19 pp., figs. 4 references.

An approximate method in which the combination of elementary conical flows due to line sources is used to describe the flow about a slender arbitrary cone. The parameters used to determine such a system of sources are the spacing of the sources around the axis lying in the flow direction, the slope relative to the flow, the number of sources, and their strength. The first three parameters are determined by the facts that the same symmetries will hold for the sources and the body, that the distance from a peak to a source will be less than or equal to the radius of curvature at that point, and that for an elongated body the slenderer the section the closer together the sources must be. The method can be used for the case of conical body at an angle of attack and in yawed flight.

Compressible Flow Tables for Air. Marie A. Burcher. *U.S., N.A.C.A., Technical Note No. 1592*, August, 1948. 33 pp., figs. 2 references.

Contains a tabulation of functions of the Mach Number which are frequently used in high-speed aerodynamics. The tables extend from $M = 0$ to $M = 10.0$ in increments of 0.01 and are based on the assumption that air is a perfect gas having a specific-heat ratio of 1.400.

The Flow of a Compressible Fluid Past a Circular Arc Profile. Carl Kaplan. *U.S., N.A.C.A., Report No. 794*, 1944. 26 pp., figs. 11 references. U.S. Govt. Printing Office, Washington. $0.20.

A Method for Determining the Aerodynamic Characteristics of Two- and Three-Dimensional Shapes at Hypersonic Speeds. H. Reese Ivey, E. Bernard Klunker, and Edward N. Bowen. *U.S., N.A.C.A., Technical Note No. 1613*, July, 1948. 21 pp., figs. 7 references.

Energy Decay and Self-Preserving Correlation Functions in Isotropic Turbulence. G. K. Batchelor. *Quarterly of Applied Mathematics*, Vol. 6, No. 2, July, 1948, pp. 97–116, figs. 14 references.

An examination of the energy decay in a turbulent fluid that is spatially homogeneous, isotropic, and in which the mean motion is zero. The conditions for both small and large Reynolds Numbers are determined under which the correlation functions display complete self preservation during decay of turbulence and under which they display partial self preservation when the time of decay is not large. The mathematical deductions agree with experimental measurements but do not constitute a solution to the problem of the decay of isotropic turbulence.

Forces Exerted on a Rigid Cylinder in a Viscous Fluid Between Two Parallel Fixed Planes. O. H. Faxén. (Recd. September 30, 1944.) (*Ingeniörsvetenskapsakademi, Handlingar Nr. 187*, 1946.) *Acta Polytechnica* (Stockholm), No. 2 (*Physics and Applied Mathematics Series*, Vol. 1, No. 1), 1947. 13 pp., figs. Sw. Kr. 2:50.

Resistance formulas are calculated under the assumptions that (1) the cylinder is moving in the fluid parallel to the planes and in the plane midway between them, with the fluid at rest at a distance from the cylinder and (2) the cylinder is fixed in the middle plane and the fluid is flowing between the planes past the cylinder. The result is expanded into series of λ, the quotient of the cylinder's diameter and the distance between the planes. The method may also be used in some problems of elasticity. Forty roots of the equation $\sinh 2\kappa = 2\kappa$ are calculated to ten places or more.

The Attenuation of Spherical Shock Waves in Air. Richard G. Stoner and Walker Bleakney. *Journal of Applied Physics*, Vol. 19, No. 7, July, 1948, pp. 670–678, figs. 7 references.

Fluid-Flow Diagrams; Construction to Include Velocity Head. George P. Loweke. *Mechanical Engineering*, Vol. 70, No. 8, August, 1948, p. 666.

INTERNAL FLOW

The Aerodynamics of the Gas Turbine. A. R. Howell. *Royal Aeronautical Society, Journal*, Vol. 52, No. 450, June, 1948, pp. 329–348, Discussion, pp. 348–356, illus., diagrs., figs. 47 references.

A summary of the aerodynamic problems that arise in the study of the flow of the working fluid through turbines and compressors. The data obtained from wind-tunnel investigations of two-dimensional flow through blades in cascade were interpreted by aerodynamic theory in order to obtain detailed knowledge of the lift coefficients, the drag and loss coefficients, air deflections, and the Mach Numbers permissible with various forms of ducts. The performance of an axial compressor or turbine in terms of lift drag conditions in the machine may be obtained from the cascade relationships when appropriate three-dimensional corrections are applied. This method of determining performance is worked out for a typical 50 per cent reaction compressor and for turbine blading. Conventional plants are compared with aircraft compressors and turbines by scaling the installations up or down so that their design speed is 3,000 r.p.m.

Investigation of Axial-Flow Fan and Compressor Rotors Designed for Three-Dimensional Flow. A. Kahane. *U.S., N.A.C.A., Technical Note No. 1652*, July, 1948. 58 pp., illus., figs. 5 references.

Two rotors with higher loading at the tips than that obtained with free-vortex blade design were tested to determine whether the three-dimensional theory may be used effectively to design rotors with a higher pressure rise. The rotors were designed for upstream velocities that were both axial and uniform. One was designed for approximately constant and the other for "solid-body" downstream absolute tangential-velocity distributions. At the design blade angle and through a range of quantity coefficient, radial surveys were made both upstream and downstream of the total pressure, static pressure, and flow angle. The solid-body rotor was also tested at a large value of tip clearance to determine whether the pressure rise at the tip would adversely affect the tip losses. Comparison of the results with values calculated theoretically shows that the three-dimensional theory used in conjunction with two-dimensional cascade data is sufficiently accurate for the design of high-efficiency axial-fan and compressor blading incorporating three-dimensional flows to obtain a variation in the spanwise load distribution and a consequent higher pressure rise. The tip-clearance losses of rotors highly loaded at the tips were not excessive.

Tests of High-Speed Flow in Diffusers of Rectangular Cross-Section. A. D. Young and G. L. Green. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2201*, July, 1944. 31 pp., illus., figs. 2 references. British Information Services, New York. $1.90.

All the diffusers tested had the same exit and entry areas, which were in ratio of 4:1 and diffused in one plane so that they were of constant width. The semiangles ranged from 4° to about 16°. Measurements of the losses involved, the pressure distributions along the diffuser, the total-head distributions at the exits, and schlieren observations of the flow and shock wave patterns under conditions ranging from a low entry Mach Number to well beyond the point at which the diffuser choked showed that the optimum semiangle for minimum loss was about 4–5° for Mach Numbers below choking. At entry Mach Numbers above choking, all diffusers became inefficient. The fractional total-head loss became a rapidly increasing function of the applied pressure independent of the diffuser angle. The losses in a short wide-angled diffuser can be reduced effectively by a dividing vane. The appendixes give the relation between applied pressure ratio, area ratio, and entry Mach Number for isentropic diffusion (subsonic flow); the derivation of the loss coefficient of a diffuser; and the derivation of theoretical shock-wave losses in a diffuser as a function of the applied pressure ratio.

An Investigation of Backflow Phenomenon in Centrifugal Compressors. William A. Benser and Jason J. Moses. *U.S.,*

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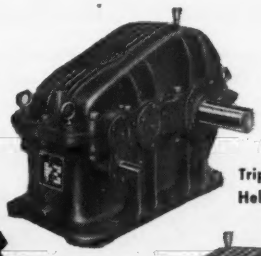

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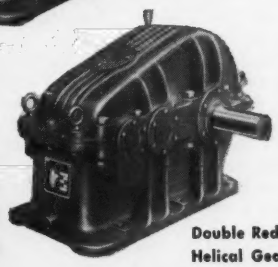

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N.A.C.A., Report No. 806, 1945. 15 pp., diagrs., figs. 4 references.

A General Representation for Axial-Flow Fans and Turbines. W. Perl and M. Tucker. *U.S., N.A.C.A., Report No. 814*, 1945. 5 pp., figs. 1 reference. U.S. Govt. Printing Office, Washington. $0.10.

PARASITIC COMPONENTS & INTERFERENCE

Effects of Nacelle Position on Wing-Nacelle Interference. Charles H. McLellan and John I. Cangelosi. *U.S., N.A.C.A., Technical Note No. 1593*, June, 1948. 87 pp., illus., diagrs., figs. 1 reference.

The interference effects between an airfoil of high critical speed with no sweepback and a nacelle of high critical speed mounted in various positions with respect to the wing were investigated to obtain a wing-nacelle combination that has the force break occurring at a Mach Number as high as that for the wing alone. This objective was realized throughout the Mach-Number range of the tests (up to 0.7) for angles of attack up to and including 2.5° with only a small loss in lift at a given angle of attack.

PERFORMANCE

Performance Changes with Design Variables. J. A. C. Williams. *Aircraft Engineering*, Vol. 20, No. 232, June, 1948 pp. 176–178, figs. 3 references.

An analytical method for determining changes in performance due to changes in any one of the design quantities upon which that performance is based. A nondimensional quantity is introduced which can be determined from known design quantities and which, under constant loading conditions, varies only with the thrust and at a limiting value of 1.0 at the absolute ceiling. The method is applicable only to small changes in the design quantities but should be valuable in design work and flight correction.

STABILITY & CONTROL

Rolling Performance of Aircraft. H. Roberts. *Aircraft Engineering*, Vol. 20, No. 232, June, 1948, pp. 167–170, 181, diagrs., figs. 8 references.

A modification of the Schrenk distribution of lift is used to obtain formulas and curves from which to estimate the values of the nondimensional coefficients which determine the angle of deflection of an aileron for a given rolling performance or the helical angle of the wing-tip path for a given aileron deflection. The results obtained for elliptic, straight-tapered, and trapezoidal wings are in reasonably good agreement with curves developed from experimental data.

Effect of Steady Rolling on Longitudinal and Directional Stability. William H. Phillips. *U.S., N.A.C.A., Technical Note No. 1627*, June, 1948. 36 pp., diagras., figs. 1 reference.

From a theoretical study of the effects of steady rolling on the longitudinal and directional stability of aircraft, it has been found that rates of roll within certain limits may cause instability if the directional and longitudinal stabilities are different. If the stabilities in both planes are equal, instability due to rolling will not occur. If the rolling frequency is sufficiently high, the rolling aircraft may be stable even if the nonrolling aircraft is unstable in one plane.

Supersonics and the Pilot. Gene May. *Western Flying*, Vol. 28, No. 8, August, 1948, pp. 10, 11, illus.

THERMO-AERODYNAMICS

Heat Transfer to Bodies Traveling at High Speed in the Upper Atmosphere. Jackson R. Stalder and David Jukoff. *U.S., N.A.C.A., Technical Note No. 1682*, August, 1948. 43 pp., figs. 16 references. (*See* AER 9/48:62.)

Temperature Gradients in the Wing of a High-Speed Airplane During Dives from High Altitudes. Thorval Tendeland and Bernard A. Schlaff. *U.S., N.A.C.A., Technical Note No. 1675*, July, 1948. 52 pp., illus., diagrs., figs. 4 references.

Observed temperature gradients that occurred in the wing of a high-speed fighter airplane during dives from 35,000 to 5,000 ft. indicated that those produced in an aircraft structure by sudden changes in surface temperature are essentially a transient condition and as such are determined mainly by the relative size (thermal capacity) of adjacent structural members and the rate of change of surface temperature. The thermal bond between adjacent structural members is also an influencing factor. Under conditions similar to the test conditions, the thermal stresses, although appreciable, are secondary in importance to the stresses arising from aerodynamic loads. Exploratory calculations indicate that the increased structural sizes required at increased diving speeds will greatly alleviate the temperature gradient problem. The assumption of perfect thermal bond between the component structures gave good agreement between the calculated and observed temperature gradients.

WINGS & AIRFOILS

Aerodynamic Characteristics of a Number of Modified NACA Four-Digit-Series Airfoil Sections. Laurence K. Loftin, Jr., and Kenneth S. Cohen. *U.S., N.A.C.A., Technical Note No. 1591*, June, 1948. 37 pp., figs. 11 references.

Wind-tunnel investigation of five modified NACA four-digit-series airfoil sections was made to show the effect of variations in the leading-edge radius and the position of maximum thickness on their aerodynamic characteristics. Data are given in cross plots for comparison with corresponding conventional four-digit and six-series low-drag sections. With normal size leading-edge radii and a maximum thickness of 12 per cent chord located at 40 per cent chord the maximum lift characteristics closely approximated those of the NACA 64-series low-drag sections of corresponding thickness and camber. Maximum lift of the 10 per cent thick airfoil sections with one-quarter normal-size leading-edge radii and maximum thickness at 40 or 50 per cent chord was 35 per cent below that of corresponding 64-series sections. When these airfoils were equipped with 20 per cent chord split flaps deflected 60° their maximum lift more nearly approached that of the 64-series. Minimum drag coefficients with maximum thickness at 40 per cent chord and normal leading-edge radius were higher than those of 64-series sections, but reduction of the leading-edge radius to one-quarter normal size and moving the position of maximum thickness to 40 and 50 per cent chord reduced the minimum drag coefficients to values about the same as those for corresponding 64- and 66-series sections, respectively. Increases in the trailing-edge angle decreased the slope of the lift curve and shifted the aerodynamic center forward.

Theoretical Wave Drag and Lift of Thin Supersonic Ring Airfoils. Harold Mirels. *U.S., N.A.C.A., Technical Note No. 1678*, August, 1948. 20 pp., figs. 7 references.

An approximate linearized solution for the wave drag and lift of a thin supersonic ring airfoil. The solution is obtained from a source distribution about a cylinder and is accurate for the limiting case of ring airfoils having small chord-radius ratios. The lift coefficient, based on the airfoil-surface area, is independent of the profile section and equals one-half the Ackeret value for a two-dimensional wing of infinite span. The drag coefficient is equal to the sum of the Ackeret value for the given profile (with the ring airfoil at zero angle of attack) and the induced drag coefficient.

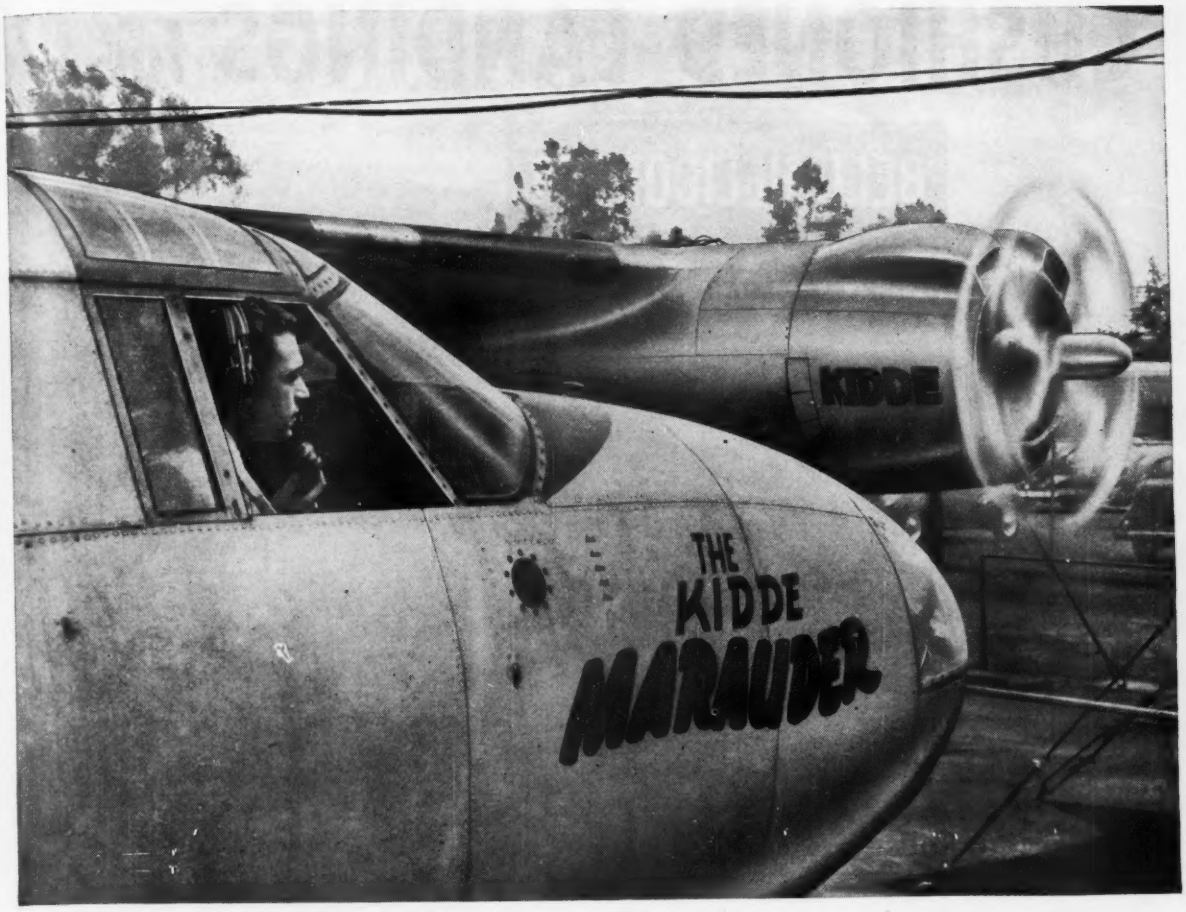
Effect of Taper Ratio on Low-Speed Static and Yawing Stability Derivatives of 45° Sweptback Wings with Aspect Ratio of 2.61. William Letko and John W. Cowan. *U.S., N.A.C.A., Technical Note No. 1671*, July, 1948. 20 pp., illus., figs. 4 references.

Results of an investigation made in the Langley stability tunnel for determining the effects of taper ratio on the static and yawing stability derivatives of wings having their quarter-chord lines sweptback 45°. All the wings had aspect ratios of 2.61 and had NACA 0012 airfoil sections normal to the quarter-chord lines. Taper ratios of 1.00, 0.50, and 0.25 were investigated. Experimental results are compared with available theory.

Low-Drag and Suction Aerofoils. II. Sydney Goldstein. (11th Wright Brothers Lecture.) *Aircraft Engineering*, Vol. 20, No. 232, June, 1948, pp. 160–165, 181, diagrs., figs.

The Oscillating Airfoil in Compressible Flow. II—A Review of Graphical and Numerical Data. S. N. Karp and H. Weil. Under the supervision of M. A. Biot. (Monograph No. 3.) *U.S., Air Force, Technical Report No. F-TR-1195-ND (GDAM A-9-M III/II)*, June, 1948. 44 pp., figs. 48 references.

A correlation of the results of the computations of aerodynamic coefficients by various authors and the associated tables and graphs of auxiliary functions, numerical data, and notation. The first chapter is restricted to those methods reviewed in "Aerodynamics of the Oscillating Airfoil in Compressible Flow" by Karp, Shu, and Weil (*Air Force Technical Report No. F-TR-1167-ND*), and for each table and graph referred to, gives the



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significance of the tabulated function, the relevant paragraphs of the basic work, and the range and interval of the argument. Functions and integrals used in the calculation of subsonic and supersonic flow, the kernel of Possio's equation, separated kernel of Possio's integral equation, special functions used in Schade's numerical method, the circulation function, and numerical values and formulas for computing the lift distribution according to Dietze's method are included. The two succeeding chapters deal with theoretical calculations of lift and moment coefficients contained in eleven papers originating in England, Germany, Italy, and the U.S. A standard notation is adopted, and a formula for transferring the moment axis to the axis of rotation in question facilitates comparison among the results of the different authors. Conversion factors are tabulated by which the results for a wing without flap at the station used by each author can be translated into the standard axes. The notations used in investigations of the effect of a flap at subsonic speeds are correlated. A generalized notation is introduced to discuss a wing with flap and tab under supersonic conditions. A table evaluated for various arguments, for the lift and moment on the wing and its components, which are caused by the beating or rotation of its elements, is constructed in terms of the lift and moment of the entire wing due to its beating or rotation about its leading edge.

Empirical Laws for the Effect of Compressibility on Quarter-Chord Moment Coefficient, and for the Choice of an Aerofoil with Small Compressibility Effects on Centre of Pressure. W. F. Hilton. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2195*, March, 1943. 16 pp., figs. 9 references. British Information Services, New York. $1.00.

An empirical relation is advanced from which the effect of compressibility on the quarter-chord moment coefficient at zero lift at subsonic speeds may be estimated. The effect given as a function of Mach Number is greater than that indicated by Glauert's relationship and agrees both with theoretical calculations by von Kármán's formula and with wind-tunnel data obtained for seven cambered airfoils. The equation reduces to the same form as Glauert's for a thin airfoil. Another equation is proposed as a possible law for the general effect of compressibility on moment coefficient which gives better agreement with experiment than does the Glauert law but which disagrees with the von Kármán formula.

Effects of Compressibility on the Flow Past Thick Airfoil Sections. Bernard N. Daley and Milton D. Humphreys. *U.S., N.A.C.A., Technical Note No. 1657*, July, 1948. 42 pp., illus., diagr., figs. 5 references.

Six 3-in.-chord symmetrical airfoils having thickness ratios from 15 to 40 per cent chord were tested at high subsonic Mach Numbers. Schlieren photographs of each airfoil showed the flow characteristics to be erratic at low supercritical speeds but improved at the highest supercritical speeds tested. Normal-force coefficients for the thick airfoils were extremely erratic at subcritical speeds but became regular at supercritical Mach Numbers. The significant factor in improving airfoil performance was the reduction of model thickness ratio.

The Practical Effects of Compressibility. C. J. O. Moorhouse. *Aeronautics*, Vol. 19, No. 2, July, 1948, pp. 30–32, figs.

A discussion of the variation in pressure distribution on upper and lower wing surfaces and the variation in overall lift coefficient for airfoils at Mach Numbers from 0.2 to 1.0. Comments on flight-test instrumentation and recording and on design features that will minimize the loss of lift at Mach 1.0 are included.

Air Power (43)

Notes on American Economy and Defense. George W. Malone. *Air Affairs*, Vol. 2, No. 3, July, 1948, pp. 346–350.

Atom Bomb: "Miracle" or Catastrophe. Lewis Mumford. *Air Affairs*, Vol. 2, No. 3, July, 1948, pp. 326–345.

The Finletter Report. Roger F. Murray, II. *Air Affairs*, Vol. 2, No. 3, July, 1948, pp. 393–403.

Sea-Based Air-Power. Cy Caldwell. *Aero Digest*, Vol. 57, No. 2, August, 1948, pp. 50, 51, 108, 110, 112, 114.

Sweden's Air Defenses. Maurice A. Smith. *Flight*, Vol. 54, No. 2065, July 22, 1948, pp. 97–100, illus.

The Truth About Aviation Today. Ben Stern. *U.S. Air Services*, Vol. 33, No. 7, July, 1948, pp. 9–12, 26, illus.

Aerial Commonwealth. *Aeronautics*, Vol. 19, No. 1, June, 1948, pp. 30–43. A survey of the status of the aircraft and air-transport industries, aeronautical research, and private flying in Canada, Australia, New Zealand, South Africa, Eire, India, Pakistan, and Ceylon.

What Can Our Bombers Do Now? An Interview with General Kenney. *Popular Science*, Vol. 153, No. 2, August, 1948, pp. 74–81, illus.

Social Effects of Aviation. Leslie A. Bryan. *Air Affairs* Vol. 2, No. 3, July, 1948, pp. 314–325.

Airplane Design & Description (10)

The Effect of Wing Planform, Speed and Height on the Design of Large Aircraft. P. E. Montagnon and D. M. Hallowes. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2146*, November, 1945. 15 pp., figs. 8 references. British Information Services, New York. $1.00.

An investigation of the variation of the pay load with changes in cruising speed and altitude and the variation of the optimum values of aspect ratio, wing loading, and all-up weight for transport aircraft with maximum percentage pay load. The percentage all-up weight carried as pay load is, to the first order, insensitive to aspect-ratio variation. With the optimum wing loading, an aspect ratio of 10 always gives nearly maximum results. At speeds above 200 m.p.h. the pay load falls off rapidly with increased speed over a given range. The optimum wing loading increases with speed and altitude and reaches a value of about 70 lbs. per sq.ft. at a speed of 350 m.p.h. at 30,000 ft. At those speeds in the range below where the pay load starts to fall off rapidly, a wing loading much above 50 lbs. per sq.ft. never appears to be necessary. The all-up weight itself seems to be a minor variable in determining percentage pay load. Flat optimum values are indicated which increase with the cruising speed. The pay-load characteristics of a flying boat are, in general, less favorable than those of a landplane but improve with increasing weight and decreasing speed. At 200 m.p.h. and with a weight of 240,000 lbs., they seem to be equivalent.

Size in Transport. Arthur Gouge. *Royal Aeronautical Society, Journal*, Vol. 52, No. 451, July, 1948, pp. 407–438, illus., figs.

The history of transportation shows that the stagecoach and omnibus, the railroad, and the ocean-going steamship have each increased in size, power, and pay load to a limit determined by operating conditions or by the capacity of the permanent structures and installations of the transportation system. The frequency of departure of any system tends to display a reciprocal relation to the duration of the journey as long as the size of the vehicle is dictated solely by the traffic density. In each case the most efficient operation was obtained with the largest vehicle. The progressive development of the airplane, the flying boat, and the airship shows the same trends as other modes of transportation. Curves are developed for the weight of aircraft per passenger against the all-up weight for different ranges. These show that the larger the aircraft, the more efficiently and economically it may be operated. In view of the restrictions on size, and, hence, on efficiency, that have been imposed on other vehicles by the fixed capital outlay required for operating facilities, aircraft should be designed specifically for the route they are to serve, and the estimated traffic density should determine the size of the craft. A route so planned, operating over a distance of 250 miles between two cities with populations of over a million, would be profitable and, using existing airport facilities, would provide superior service. Aircraft designed for a daily transatlantic service should accommodate 600 persons to provide for an estimated 200,000 flights per year by British subjects from the British Isles to foreign points and return. Such a design could be realized most economically as a flying boat because of the prohibitive cost of the air terminals that would be required to accommodate a land-based craft of this size.

Are Single Seat Fighters Out? Malcolm Cagle. *Flying*, Vol. 43, No. 2, August, 1948, pp. 32, 74, 75, illus.

What Operators Want in Cargo Aircraft. John J. Casey, Jr., and R. Dixon Speas. *SAE Journal*, Vol. 56, No. 7, July, 1948, pp. 49–52, illus. (Extended summary of a paper: Cargo Aircraft Requirements.)

Aircraft Performance Considerations. I. *Aircraft*, Vol. 26, No. 9, June, 1948, pp. 16, 46. A brief survey of the performance characteristics of an aircraft as they affect the pay load, operating speed, utilization, operating cost, and initial cost of an aircraft.

The Evolution of the Design of an Aeroplane. *Royal Aeronautical Society, Journal*, Vol. 52, No. 450, June, 1948, pp. 357–366, Discussion, pp. 366–382, diagrs. 3 references.

A description of the successive steps in the production of a new airplane design from the initial submission of proposed specifications by the customer through the completion of a prototype ready for flight testing. A discussion of the pitfalls that may arise in the development of a typical commercial aircraft shows how they may impair the ultimate efficiency of the design, how they can protract the development time, and how they may best be avoided. The manufacturer must effect a compromise between the wishes of the customer, the facilities at his disposal, and the ultimate aerodynamic efficiency of the airplane. The designer must correlate and integrate the activities of the drafting, research, testing, and production departments of the manufacturing firm. The internal rivalry that is common among the departments could best be reduced by broadening the education of all the specialists so that the draftsmen, the structures men, and the power-plant specialists would each appreciate the problems of the other.

The Evolution of the Design of an Aeroplane. R. L. Lickley. *The Engineer*, Vol. 186, No. 4824, July 9, 1948, pp. 44, 45. (Extended summary of a paper.)

The AF'S New Designation System. Charles O. Probst. *Flying*, Vol. 43, No. 2, August, 1948, pp. 36, 37, 56, illus. With table of current A.F. aircraft.

Report on Visibility Studies of Exterior Color Schemes for Aircraft at Present Aluminum Colored. Henry G. Wagner and Irene C. Blasdel. *U.S., Bureau of Aeronautics (Navy Dept.), Report No. TED NAM AE-525044*, May 18, 1948. 60 pp., illus., figs. 17 references.

Preliminary studies and tests showed that background conditions against which air-borne aircraft may be viewed can be given equivalents on the gray scale ranging from white to black. In selecting a suitable color scheme preference was given to the standard Navy paints of which glossy sea blue was selected as the component to be used with aluminum. Studies were then undertaken of the visibility of patterns of glossy sea blue on aluminum against backgrounds of white, gray, and black. The results of 22,176 observations of 37 different combinations of paint schemes on model aircraft viewed under controlled laboratory conditions by 122 different observers show that glossy sea blue applied to the trailing halves of the empennage and wing surfaces improved the visibility of an aluminum-colored aircraft more than any other scheme tested.

Track Gear Promises High Utility; New C-82 Installation Developed by Fairchild and Firestone. Alexander McSurely. *Aviation Week*, Vol. 49, No. 1, July 5, 1948, pp. 21, 22, illus., fig.

The Flying Runway (Track-Tread Landing Gear). R. W. Allen. *Western Flying*, Vol. 28, No. 8, August, 1948, pp. 8, 9, illus.

"Flying Runway" Strategy (Track-Tread Landing Gear). *Aero Digest*, Vol. 57, No. 1, July, 1948, p. 25, illus.

Cross Wind Landing Gear. C. O. Bell. *Western Flying*, Vol. 28, No. 8, August, 1948, pp. 14, 15, illus.

Castered Gear for Safety & Saving. Alice Rogers Hager. *Skyways*, Vol. 7, No. 7, July, 1948, pp. 21, 39, 44, illus.

Services Investigate Utility of (Wheel and) Ski Gear. *Aviation Week*, Vol. 49, No. 3, July 19, 1948, p. 30, illus.

Built-In Airstrip; Moving Weight on a Track Improves Landing Performance of Lightplanes. Lawrence Keil. *Flying*, Vol. 43, No. 3, September, 1948, p. 33, illus.

Power Controls (Electro-Mechanical) for the SR-45 Flying-Boat. *The Aeroplane*, Vol. 75, No. 1936, July 16, 1948, pp. 87, 88, diagrs.

Power-Operated Controls; New Electro-Hydraulic System Developed for the Saro SR 45. *Flight*, Vol. 54, No. 2064, July 15, 1948, pp. 75, 76, diagr.

Some Interesting Projects. D. L. Brown. *The Aeroplane*, Vol. 75, No. 1935, July 9, 1948, pp. 43–46, illus., diagrs.

A review of a few aircraft designs projected between 1935 and 1945 but never actually built. These include orthodox and unorthodox bombers, fighters, transports, gliders, trainers, and communication craft. Among them are: the B.1/35, B.1/39, B.8/41, and B.11/41 bombers, the T.23/43 trainer, and the A.4/45 reconnaissance aircraft; the Miles M.58 composite naval patrol fighter; the Short tailless long-range transport; the Armstrong Whitworth tail-first fighter; the Miles M.46 flying test bed; and the X14 long-range transport.

Soviet Curtain Raisers. *The Aeroplane Spotter*, Vol. 9, No. 215, June 12, 1948, pp. 138, 139, illus., diagrs. The Tupolev twin-jet attack bomber, a sonic-research single-seater monoplane, a single-seater twin-jet fighter, and the Iliushin four-jet medium bomber.

New Russian Aircraft. *The Aeroplane*, Vol. 54, No. 1932, June 18, 1948, pp. 718, 719, illus.

Illustrations of four Russian aircraft: a single-seater fighter, probably designed by Mikoyan, with a straight-through-flow power plant; a development of the T.U.2, with two turbojet units mounted in nacelles, designed by A. N. Tupolev; an Iliushin four-jet medium bomber with underslung jet units; and two types of single-seater monoplane with swept wings and tail surfaces, developed from German models and designed to penetrate the sonic barrier.

Recent Russians: Transport and Training Aircraft by Yakovlev and Iliushin. *Flight*, Vol. 53, No. 2061, June 24, 1948, pp. 696, 697, illus. The Yak-18 and Il-12 transports.

The First Jet Trainers. *Aero Digest*, Vol. 56, No. 6, June, 1948, pp. 38–40, illus. The Lockheed TF-80C, a two-seater dual-control trainer version of the P-80 and two British trainers, the Meteor VII, a variant of the Gloster Meteor, and the turboprop Athena, a three-seater model.

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Another British First; Initial Flight of Vickers Viscount with Transport Turboprop. *Flight*, Vol. 54, No. 2065, July 22, 1948, p. 89, illus.

An Unorthodox Aeroplane (Warren-Young Skycar). Norman Hall-Warren. *The Aeroplane*, Vol. 74, No. 1933, June 25, 1948, pp. 760, 761, illus., figs.

The predicted lift, pressure distribution, and performance characteristics of the Warren-Young Skycar. The Warren-Young wing consists of an integral system of sweptback front planes and swept-forward rear planes. The union of the front and rear planes are large semicircular tip surfaces. The configuration has the advantageous aerodynamic properties of both swept and tandem airfoils and eliminates the inherent limitations and defects of the conventional type of airplane. Maximum lift, which is 90 per cent of that of a conventional wing, is attained at an angle of attack of 40°.

The Nazi's Foolproof Plane (Winter Zaunkönig). *Flying*, Vol. 43, No. 3, September, 1948, pp. 38, 39, illus.

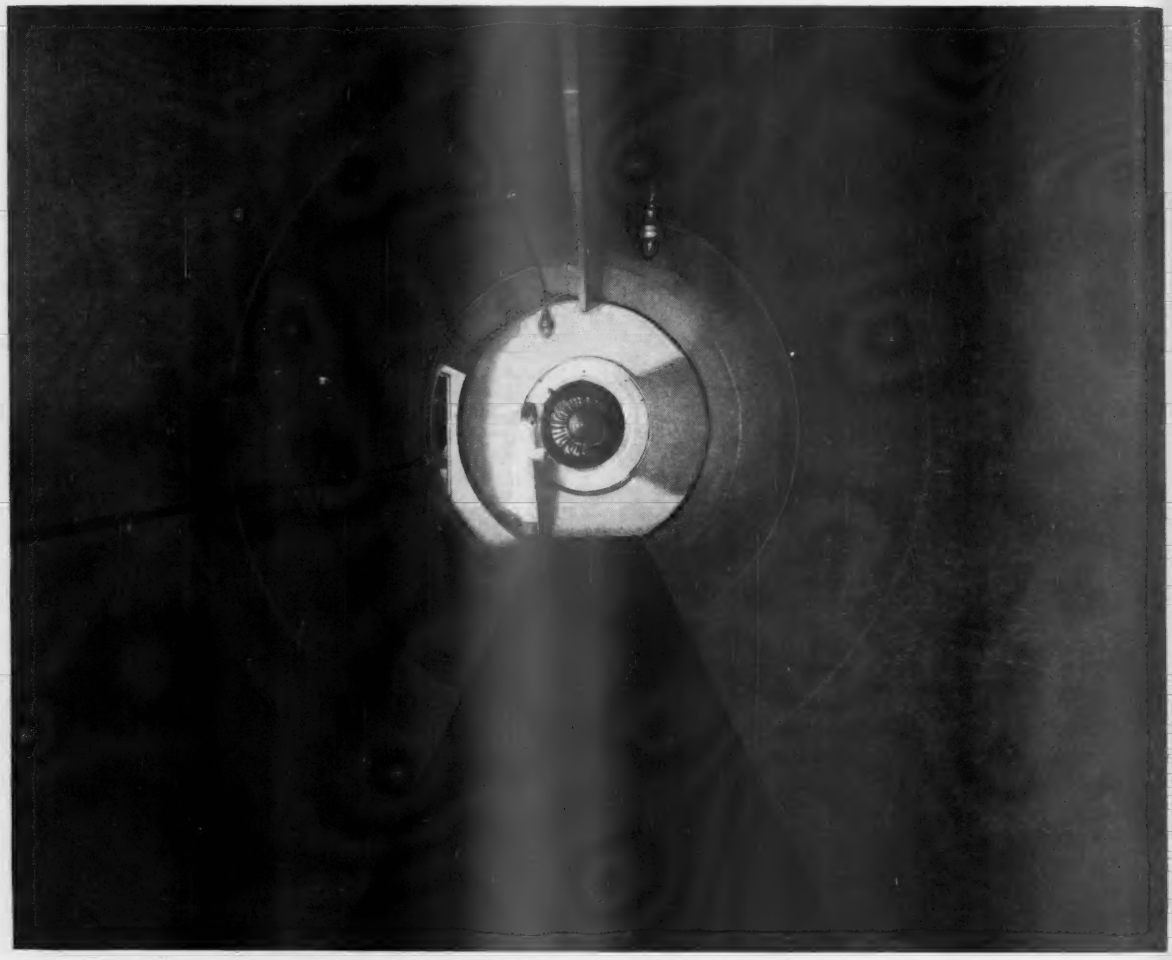
Airports & Airways (39)

The Usability of Aerodromes. *Aircraft Engineering*, Vol. 20, No. 233, July, 1948, pp. 194–199, figs.

A summary of the take-off, stalling-speed, rate-of-climb, approach, and en-route performance requirements that have been adopted in Australia. The restrictions determine the runway length, clearance, and density altitude required by an aircraft at a given weight and, hence, the usability of an airport. The selection of the runway at an airport to be used under a particular set of wind conditions has been facilitated by the introduction of runway selection diagrams. Instantaneous wind conditions can be represented on these by a point, and the color of the region of the chart in which it falls serves as a code to the appropriate runway. In the design of an airport its usability can be determined from a comprehensive analysis of the percentage of winds in various directions and their strength. The cost of runway construction and maintenance can be reduced for air-line operations by the adoption of single runways or two-runway systems. This would require commercial aircraft to be designed to cope with cross-wind components of 20 m.p.h. or higher, and the improvement of the technique for operation in strong cross winds.

Visual Aids for Low Visibility Conditions. E. S. Calvert. *Royal Aeronautical Society, Journal*, Vol. 52, No. 451, July, 1948, pp. 439–466, Discussion, pp. 467–476, illus., figs.

Prior to 1938, visual landing aids in England attempted primarily to reproduce daylight landing conditions. Subsequent development of airport, lead-in, approach, and runway-lighting patterns had limited visibility, were rendered ineffective by extraneous light, could not be used during the day, and were not adaptable to radio-aided approaches. High-intensity approach and runway lighting systems that were developed as a part of integrated landing systems were difficult to use in limited visibility because the absence of a horizon reference made it necessary for the pilot to calculate from a limited visible field the location of the vanishing point of the parallel lines of lights. Pilots also experienced difficulty in changing over from an instrument approach to contact landing. In order to find a pattern that the pilot can interpret instantly, instinctively, and correctly down to a meteorological visibility of 200 yards in daylight, a series of perspective diagrams was made at the R.A.E. which showed in outline exactly what the pilot sees at various stages of the approach and landing. It was found that directional indication is best provided by a single line of lights located along the extended centerline of the runway. A pattern was developed consisting of a centerline of lights with bars of lights arranged at intervals across it. By decreasing successively the width of each cross bar from the beginning of the approach to the runway, threshold indication of alignment, bank, and glide path can be obtained from the pattern in a manner that is free from ambiguity even



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when only a small portion of the whole pattern is seen. Tests of this pattern with a simulator, in which the operation of aircraft controls reproduced in the instrument the lighting pattern as it would appear in the pilot's field of vision, and flight tests on an experimental installation at Farnborough have confirmed the advantages of the system.

Air-Approach Facilities at New York International Airport. George M. McSherry. *Aero Digest*, Vol. 57, No. 1, July, 1948, pp. 23, 24, 113, 114, illus.

Light Beam Glide Path (Aviation Equipment Corp.). R. E. Stockwell. *Southern Flight*, Vol. 30, No. 1, July, 1948, pp. 21, illus., diagr.

Newark's High Intensity Approach Lighting. John F. Gill. *Airports and Air Carriers*, Vol. 14, No. 1, July, 1948, pp. 22, 23, illus.

Airport Lighting Survey. G. Silvering. *Airports and Air Carriers*, Vol. 14, No. 1, July, 1948, pp. 14, 16.

Replies to questionnaires submitted to 948 airports, constituting an overall response of 24 per cent, are analyzed by size of airport to show the present status of airport lighting, types of installations, and the cost of installations proposed during the coming year.

Lighting for Small and Large Airports. *Aviation Maintenance & Operations*, Vol. 10, No. 3., August, 1948, pp. 50–57, diagrs. General considerations, standards, typical layouts, C.A.A. specifications, high-intensity approach and runway lighting, distribution systems for controllable-beam and fixed-focus bidirectional and fixed-focus unidirectional high-intensity runway lights.

Heir-Ports. Donald Bennett. *Aeronautics*, Vol. 19, No. 1, June, 1948, pp. 75, 76, 78.

The dispersion of the British Empire provides the sites for enough free airports to serve a system of air-transport trunk lines to unite the Commonwealth into an economic whole. The minimum requirements of such mainline airports and future prospects are considered.

Airports of the World: Jersey, Channel Islands' Terminal. Basil C. de Guerin. *Airports & Air Transportation*, Vol. 3 (N.S.), No. 62, July–August, 1948, pp. 9–12, illus.

A Picture of Idlewild Now and Tomorrow. James C. Buckley. *Air Transportation*, Vol. 13, No. 1, July, 1948, pp. 8–10, 40, 41, illus.

Fuhlsbüttel—Hamburg's Airport. *The Aeroplane*, Vol. 74, No. 1932, June 18, 1948, pp. 735–736, illus.

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Operations Begin at New York International. *American Aviation*, Vol. 12, No. 5, August 1, 1948, pp. 36–38, illus.

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Sweden's International Airport (Stockholm-Bromma). *Shell Aviation News*, No. 121, July, 1948, p. 8, illus.

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Growth of a Multiple Airport City of 300,000 Population (Denver, Colo.). *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, pp. 48, 49, figs.

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Airport Projects Listed for 1949 (Federal-Aid Airport Program). *Aviation Week*, Vol. 49, No. 2, July 12, 1948, pp. 12, 13.

Airport Leases and Contracts. Allen H. Barr. *Southern Flight*, Vol. 30, No. 2, August, 1948, pp. 34, 35, 37.

Increasing Airport Income. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, p. 62.

Airport Cash Register. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, p. 63. Planning and operation of terminal buildings to obtain maximum revenue.

Airport Accounting. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, pp. 66–70, tables.

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Increasing Non-Aviation Revenues. Louis R. Inwood. *Airports and Air Carriers*, Vol. 14, No. 1, July, 1948, pp. 8, 9, illus.

All Purpose Grass for Airports. Chan W. Baker. *Airports and Air Carriers*, Vol. 14, No. 1, July, 1948, p. 31, illus.

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Check Chart for Airport Fire Prevention. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, pp. 99–106.

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All-Weather Flying (31)

Safety in Storms; American Research into Thunderstorm Flying (U.S.A.F. All-Weather Flying Division). *Flight*, Vol. 53, No. 2061, June 24, 1948, p. 682, illus.

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ICE PREVENTION

A Study of Wing De-Icer Performance on Mount Washington. Dwight L. Loughborough, Howard E. Greene, and Paul A. Roush. *Aeronautical Engineering Review*, Vol. 7, No. 9, September, 1948, pp. 41–50, illus., diagrs., figs. 18 references.

The weather at the meteorological observatory on the peak of Mt. Washington provides icing conditions on over 48 per cent of all the days of a typical year. Data have been obtained at this ocation on the kind and distribution of ice on aircraft wings, drop diameter, and liquid water content of clouds which agree well with data obtained in flight except that the relatively low wind velocity causes a preponderance of low-density ice. A nearly full-scale aircraft wing mounted as a weather vane, a fixed wing, and a device for testing the tensile strength of ice were installed to test various types of inflatable deicing equipment. The density of the ice collected appeared to depend on the fraction of the drops caught rather than the temperature, wind velocity, or drop size per se. The amount of ice collected over a finite time depended on the roughness of the ice deposit. Performance curves that were obtained show that the best performance was obtained using tubes with diameters varying from $^1/_4$ to $^3/_4$ in. cemented directly to the wing to eliminate any "stretch area." The performance of the small-tube deicers is improved by using high inflation pressures, and the efficiency of all types of installation is increased by using a high-viscosity silicone oil or elastomer to reduce the adhesion between the ice and the surface of the tube.

Atomic Energy (48)

NEPA Now Engineering Problem. *Aviation Week*, Vol. 49, No. 3, July 19, 1948, p. 29.

The nuclear Energy for the Propulsion of Aircraft Division of the Fairchild Engine and Airplane Corporation, maintains that uranium fission can be used as a source of heat energy in a closed-cycle turbine, a turbojet engine using air as a working fluid, a ram-jet engine, or a rocket unit for the propulsion of aircraft. Such power plants would have the combined advantages of high speed and high pay load. Among the chief problems presented are the shielding of the reaction pile and confining and shielding the products of fission in the event of a crash.

Atomic Engines for Aircraft. Andrew Kalitinsky. *The Pegasus*, Vol. 12, No. 2, August, 1948, pp. 1–4, 16, illus., diagrs.

Aviation Medicine (19)

High Acceleration of Short Duration. J. R. Poppen. *Military Surgeon*, Vol. 103, No. 1, July, 1948, pp. 30–32. 5 references.

A summary of the results of German, British, and U.S. investigations of the tolerance of the human body to high accelerations for brief periods. The compressibility of the human subject re-

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Relationship Between Certain Aspects of Physical Fitness and Success in Pilot Training. B. E. Phillips. *Journal of Aviation Medicine*, Vol. 19, No. 3, June, 1948, pp. 186–203, figs., tables. 9 references.

A Cumulative Record of Naval Aviator Proficiency. Howard E. Page. *Journal of Aviation Medicine*, Vol. 19, No. 3, June, 1948, pp. 211–218. 3 references.

Problems of Flight Personnel Selection and Training. Leon D. Carson. *Military Surgeon*, Vol. 103, No. 1, July, 1948, pp. 32–36.

Personnel Selection Procedures in Military Aviation. Bertram Groesbeck, Jr. *Military Surgeon*, Vol. 103, No. 1, July, 1948, pp. 16–19.

Australia's Flying Doctors. *The Aeroplane*, Vol. 54, No. 1931, June 11, 1948, pp. 705, 706, map.

Etiology of Pulmonary Hemorrhage in Cats Exposed to Abrupt Deceleration. Roger K. McDonald, Vincent C. Kelley, and Robert Kaye. *Journal of Aviation Medicine*, Vol. 19, No. 3, June, 1948, pp. 138–145, illus., figs. 7 references.

Effects of Angular Acceleration and Centrifugal Force on Non-visual Space Orientation During Flight. Kenneth MacCorquodale. *Journal of Aviation Medicine*, Vol. 19, No. 3, June, 1948, pp. 146–157, tables. 3 references.

Aviator's Vertigo. W. Edgar Vinacke. *Journal of Aviation Medicine*, Vol. 19, No. 3, June, 1948, pp. 158–170, tables. 18 references.

Quantitative Histochemical Changes in the Adrenal Following Exposure to Anoxia. John Nichols. *Journal of Aviation Medicine*, Vol. 19, No. 3, June, 1948, pp. 171–178, figs. 29 references.

Certain Pharmacological Properties of Alcohol, Nicotine and Caffeine. Orville Horwitz. *Journal of Aviation Medicine*, Vol. 19, No. 3, June, 1948, pp. 179–185, 203. 21 references.

Studies on the Removal of Gas from the Colon by Oxygen Inhalation. R. S. Pogrund and F. R. Steggerda. *Journal of Aviation Medicine*, Vol. 19, No. 3, June, 1948, pp. 204–210, figs. 18 references.

Engineering and the Medical Sciences. Luis de Florez. *Mechanical Engineering*, Vol. 70, No. 8, August, 1948, pp. 661, 662, 682.

Aircraft as Pest Destroyers; Scientists Help to Solve Vital African Disease Problem. K. G. Coleman. *Airports & Air Transportation*, Vol. 2 (N.S.), No. 61, June, 1948, pp. 455, 456, illus.

Comfortization (23)

Factors Affecting Transport Air Conditioning and Pressurizing System Design. P. E. R. Brice. *Aero Digest*, Vol. 57, No. 1, July 1948, pp. 48–51, 109, 110, 112, figs.

A discussion of the standards for air and wall temperatures, rate of air replacement and distribution, and pressure variation in air-conditioned and pressurized aircraft cabins. If a carbon-dioxide level of 10 parts in 10,000 is to be maintained, 20 cu.ft. of fresh air per person per min. must be supplied to the cabin. Even though this is in excess of the rate required for breathing and the rate needed to maintain an optimum evaporative heat loss on the skin, it should be increased to 24 cu.ft. per min., assuming an air space of 100 cu.ft. for each person, in order to remove body odors. Passengers' comfort requires that the rate of change of pressure in the cabin be less than that corresponding to a change in altitude of 300 ft. per min. In order to provide for the contingency of explosive decompression, the rate of descent of an airplane should be such that the crew and passengers will not be exposed to high-altitude conditions for a period of time greater than that during which useful consciousness is retained at high altitudes.

High Speed Turbine Cooling Unit. *Product Engineering*, Vol. 19, No. 6, June, 1948, illus., diagr.

Developed by AiResearch Manufacturing Company. The expansion turbine can produce a 135°F. temperature drop at 7-lb. airflow per min. Hot pressurized air, bled from the engine compressor, passes through heat exchanger to an expansion turbine unit. A fan mounted on the same shaft as the turbine circulates ambient coolant air through the heat exchanger.

Comfort in the Air; Useful Range of Furnishing Items Now Standardized by Vickers; Electrically Operated Chairs, Food Container Units. *Flight*, Vol. 54, No. 2065, July 22, 1948, pp. 94, 95, illus.

Electronics (3)

Surveillance Radar Deficiencies and How They Can Be Overcome. J. Wesley Leas. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 8, August, 1948, *Waves and Electrons Section*, pp. 1015–1017.

Ground Control Approach Radar (R.C.A.F. Radar Landing Facilities). Ronald A. Keith. *Canadian Aviation*, Vol. 21, No. 7, July, 1948, pp. 26, 27, illus.

Recent Canadian Radar. B. G. Ballard. *The Engineering Journal*, Vol. 31, No. 7, July, 1948, pp. 373–381, 391, illus., figs.

Operational Trials of the Australian Distance Measuring Equipment and Multiple Track Radar Range. J. G. Downes. *Australia, Council for Scientific and Industrial Research*, 1948. 15 pp., illus., figs. (*Reprint, Institution of Radio Engineers, Australia, Proceedings*, Vol. 9, No. 4, April, 1948, pp. 10–23.)

Daytime Radar Reading Eased. *Aviation Week*, Vol. 49, No. 3, July 19, 1948, pp. 34, 37, illus.

A display-repeater system developed by E. G. Bowen of the Radiophysics Division of the Australian Council for Scientific and Industrial Research. An operator at a plane-position-indicator, set in a normally dark recess of the console of a radar receiver, traces with a stylus the tracks of all aircraft within radar range. Wires attached to the tip of the stylus wrap around shafts of two transmitting selsyns, which drive the receiving selsyns and the writing point of the daylight display. This repeater system produces an enlarged version of the original cathode-ray, tube display on a paper screen impregnated with potassium iodide sodium carbonate, and starch. A d.c. voltage applied to the writing point electrolyzes the potassium iodide to produce iodine, which discolors the starch, thus producing a visible blue trace.

Approach Control Radar (Developed by the Australian C.S.I.R. with the Department of Civil Aviation). *Aircraft*, Vol. 26, No. 9, June, 1948, pp. 12, 13, 36, illus.

Very-High-Frequency Single-Channel Receiver. W. C. Lane and T. C. Clark. *Electrical Communication*, Vol. 25, No. 2, June, 1948, pp. 132–138, illus., figs. A crystal-controlled ground-station receiver operating in the range of 118–136 mc. It employs a 14-tube superheterodyne circuit, incorporating automatic-volume-control, squelch, and noise-limiter circuits.

Radio Communication for Aircraft; A Development by E. K. Cole, Ltd. *Electronic Engineering*, Vol. 20, No. 245, July, 1948, p. 233, illus. A twin-channel ground and air installation operating in the frequency range of 118–128 mc.

VHF Radio Bands. *Airports and Air Carriers*, Vol. 14, No. 1, July, 1948, p. 17, illus.

T. R. E., The Telecommunications Research Establishment at Great Malvern. *Electronic Engineering*, Vol. 20, No. 245, July, 1948, pp. 206, 207, illus.

A Duplex System of Communications for Microwaves. R. V. Pound. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 7, July, 1948, pp. 840–844, illus., diagrs. 2 references.

The properties of a communication system obtained by the use of a single microwave oscillator as both transmitter and beating oscillator of a superheterodyne receiver. The oscillator is stabilized in frequency by an electronic circuit at the frequency of a high-Q cavity and frequency-modulated about this stabilization frequency. The resultant communication sets are capable of simple duplex communication in pairs, and evidence that he is being received at the other station is given to the operator initiating communication. The system is applicable to communication from ground to aircraft, utilizing the large number of channels available in the microwave region. It is also suitable as a booster station for a relay link. An experimental version of this set was built.

Field Theory of Traveling-Wave Tubes. L. J. Chu and J. D. Jackson. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 7, July, 1948, pp. 853–863, figs. 8 references.

Attenuator Materials for Microwave. G. K. Teal, M. D. Rigterink, and C. J. Frosch. *Electrical Engineering*, Vol. 67, No. 8, August, 1948, pp. 754–757, figs.

Effect of Passive Modes in Traveling-Wave Tubes. J. R. Pierce. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 8, August, 1948, pp. 993-997, figs. 4 references.

Experimental Results on Standing Wave Type Linear Accelerators for Electrons. Elliott J. Lawton and W. C. Hahn. *Journal of Applied Physics*, Vol. 19, No. 7, July, 1948, pp. 642–648, diagr., figs. 6 references.

Rising Sun Magnetrons with Large Numbers of Cavities. A. V. Hollenberg, N. Kroll, and S. Millman. *Journal of Applied Physics*, Vol. 19, No. 7, July, 1948, pp. 624–635, figs. 7 references.

Certain Matters Concerning Scaling in the Magnetron with Special Reference to the Relative Efficiency of Magnetrons of Different Sizes. W. F. G. Swann. *Franklin Institute, Journal*, Vol. 246, No. 2, August, 1948, pp. 149–157, figs.

Universal Curves for Dielectric-Filled Wave Guides and Microwave Dielectric Measurement Methods for Liquids. W. H. Surber, Jr. *Journal of Applied Physics*, Vol. 19, No. 6, June, 1948, pp. 514–523, figs. 7 references.

$TM_{0,1}$ Mode in Circular Wave Guides with Two Coaxial Dielectrics. Sidney Frankel. (*Journal of Applied Physics*, Vol. 18, July, 1947, pp. 650–655.) *Electrical Communication*, Vol. 25, No. 2, June, 1948, pp. 152–157, figs. 2 references.

A Method for Measuring the Complex Dielectric Constant of Gases at Microwave Frequencies by Using a Resonant Cavity. C. K. Jen. *Journal of Applied Physics*, Vol. 19, No. 7, July, 1948, pp. 649–653, figs. 10 references.

Results of Horizontal Microwave Angle-of-Arrival Measurements by the Phase-Difference Method. A. W. Stratton and J. R. Gerhardt. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 7, July, 1948, *Waves and Electrons Section*, pp. 916–922, illus., maps. 5 references.

A Method of Determining the Angle of Arrival. A. W. Stratton W. E. Gordon, and A. H. LaGrone. *Journal of Applied Physics*, Vol. 19, No. 6, June, 1948, pp. 524–533, figs. 1 reference.

A Note on the Phase Difference Between Two Waves Reflected from the Ionosphere. J. M. Kelso. *Journal of Applied Physics*, Vol. 19, No. 6, June, 1948, pp. 590, 591, figs. 2 references.

The General Problem of Antenna Radiation and the Fundamental Integral Equation, with Application to an Antenna of Revolution. I. G. E. Albert and J. L. Synge. **II.** J. L. Synge. *Quarterly of Applied Mathematics*, Vol. 6, No. 2, July, 1948, pp. 117–131, 133–156, 8 figs. 6 references.

The Radiation and Transmission Properties of a Pair of Semi-Infinite Parallel Plates. I. Albert E. Heins. *Quarterly of Applied Mathematics*, Vol. 6, No. 2, July, 1948, pp. 157–166, fig. 4 references.

Antennas for Circular Polarization. W. Sichak and S. Milazzo. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 8, August, 1948, pp. 997–1001, figs. 5 references.

Investigations of High-Frequency Echoes. H. A. Hess. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 8, August, 1948, pp. 981–992, figs. 9 references.

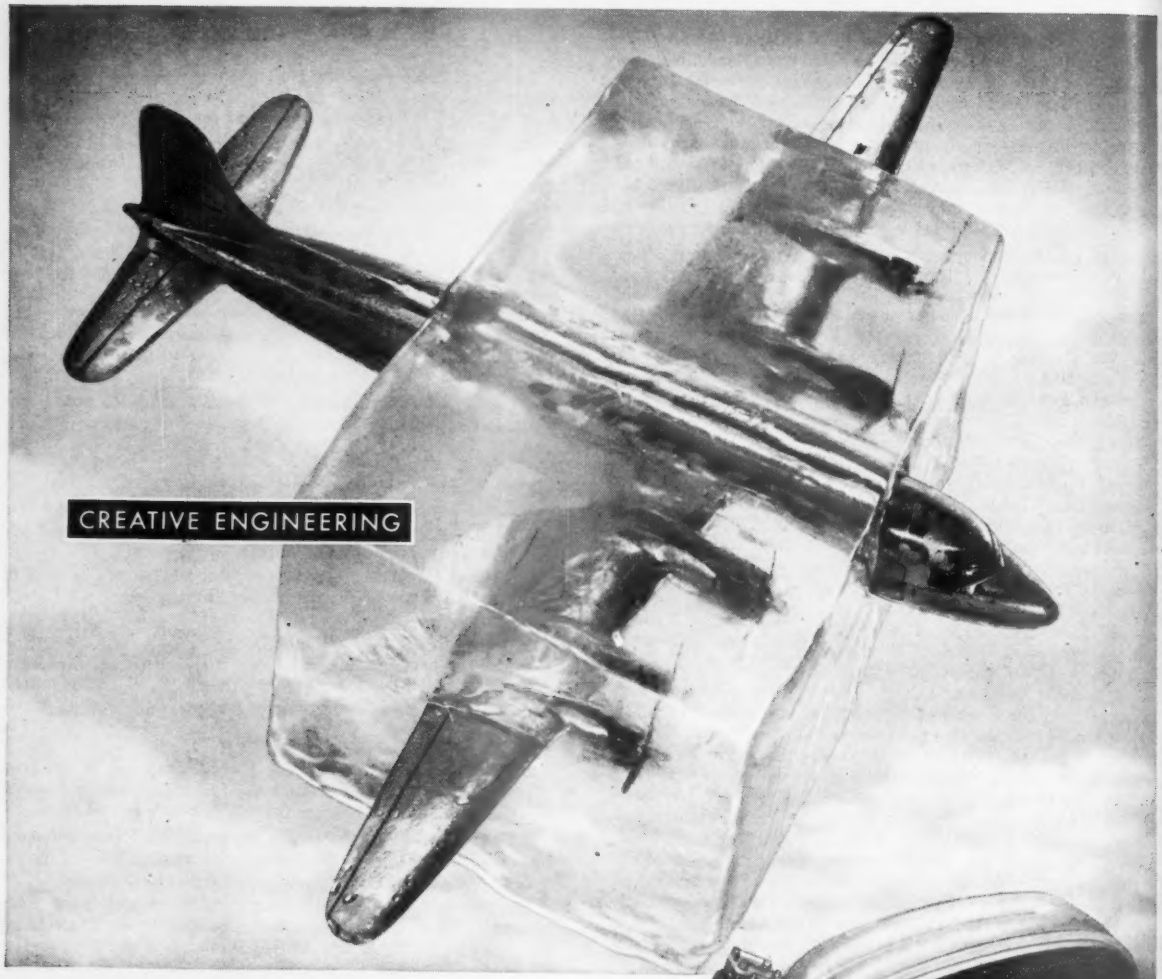
The Luxembourg Effect in Radio Communications. David K. Cheng. *Chinese Institute of Engineers, Journal*, Vol. 10, No. 1, May, 1948, pp. 66–72. 20 references.

A Study of the Interaction of Radio Waves. J. A. Ratcliffe and I. J. Shaw. *Royal Society of London, Proceedings, Series A*, Vol. 193, No. 1034, July 2, 1948, pp. 311–343, figs. 17 references. Luxembourg effect.

High Gain with Discone Antennas. A. G. Kandoian, W. Sichak, and R. A. Felsenheld. (*National Electronics Conference, Chicago, November, 1947, Proceedings*, Vol. 3, pp. 336–346.) *Electrical Communication*, Vol. 25, No. 2, June, 1948, pp. 139–147, illus., figs. 4 references.

On Antenna Impedances. Erik Hallén. (*Kungl. Tekniska Högskola, Handlingar Nr. 13*, 1947.) *Acta Polytechnica* (Stockholm), No. 16 (*Electrical Engineering Series*, Vol. 1, No. 4), 1947. 18 pp., figs. Sw. Kr. 2.

Contains a complete table of the terms of the numerator and denominator in Hallén's antenna impedance formula. The table associated with that formula computed by Bouwkamp is found unreliable, whereas that of King and Blake is good but contains only the first order terms. Some admittance diagrams are drawn.



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The Field of a Dipole with a Tuned Parasite at Constant Power. Ronold King. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 7, July, 1948, pp. 872–876, figs. 6 references.

Measurement of the Dielectric Properties of Soils and Water at 3.2 Wave Length. A. W. Stratton and C. W. Tolbert. *Franklin Institute, Journal*, Vol. 246, No. 1, July, 1948, pp. 13–20, figs. 4 references.

The Radiation Patterns of Dielectric Rods—Experiment and Theory. R. B. Watson and C. W. Horton. *Journal of Applied Physics*, Vol. 19, No. 7, July, 1948, pp. 661–670, figs. 1 reference.

An Electronic Switch; Designed to Convert a Single Beam Oscilloscope into a Double Beam Oscilloscope. D. W. Davidson. *Electronics Forum*, No. 9, March, 1948, pp. 24–28, fig.

Cathode-Ray Oscilloscope Camera. D. D. Bare. *Review of Scientific Instruments*, Vol. 19, No. 7, July, 1948, pp. 471–473, illus., figs.

Cathode-Ray Magnetization Curve Tracer. M. V. Scherb. *Review of Scientific Instruments*, Vol. 19, No. 7, July, 1948, pp. 411–419, illus., diagrs. 10 references.

Magnetic hysteresis loops can readily be obtained for specimens in rod, powder, tape, or wire form having cross-sectional areas as small as 10^{-5} cm.$^{-2}$ ($^1/_4$-in. rod). With slight modifications, the instrument can be adapted to magnetic measurements of materials as a function of frequency, temperature, tension, torsion, or pressure, using the appropriate setup.

The Luminescence of Simple Oxide Phosphors. R. B. Head. *Electronic Engineering*, Vol. 20, No. 245, July, 1948, pp. 219–226, tables.

A qualitative investigation. Luminescence of metals under cathode-ray recitation generally appears to be confined to the oxides of metals occurring in Groups II, III, and IV of the periodic table. Since oxides possessing low heats of formation displayed ion and electron burn, the investigation was confined mostly to calcium, strontium, and barium oxides. Every element, almost without exception, produces a characteristic fluorescence, even iron, nickel, and cobalt when used as activators with calcium oxide. The color of fluorescence is insensitive to the concentration of the activator and depends entirely on its chemical state. There is a connection between the color of fluorescence and the position of the activator in the periodic classification. Strontium oxide forms few phosphors, and barium oxide forms no phosphors fluorescing in the visible range unless a proportion of berryllia is present. Tables in color show the color and brightness response of unactivated oxides, calcium oxide phosphors, and strontium oxide.

Spectral Power Distribution of Cathode-Ray Phosphors. R. M. Bowie. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 8, August, 1948, *Waves and Electrons Section*, pp. 1023–1029, figs. 15 references.

Megacycle Stepping Counter. C. B. Leslie. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 8, August, 1948, *Waves and Electrons Section*, pp. 1030–1034, diagrs., figs. 2 references.

A Precision High Voltage Vacuum-Tube Voltmeter. Luke C. L. Yuan. *Review of Scientific Instruments*, Vol. 19, No. 7, July, 1948, pp. 450–452, figs. 3 references.

An Improved Peak Voltmeter for Pulses. Y. P. Yu. *Review of Scientific Instruments*, Vol. 19, No. 7, July, 1948, pp. 447–450, figs.

A Spiral Chronograph for Long Time Intervals. H. D. Warshaw. *Review of Scientific Instruments*, Vol. 19, No. 7, July, 1948, pp. 420–423, figs. 2 references.

An Automatic Impedance Meter. Hans Werthén and Björn Nilsson. (*Kungl. Tekniska Högskola, Handlingar Nr. 8*, 1947.) *Acta Polytechnica* (Stockholm), No. 12 (*Electrical Engineering Series*, Vol. 1, No. 3), 1947. 95 pp., illus., figs. 25 references. Sw. Kr. 4:50.

The meter was designed and constructed at the Department of Radio Engineering of the Royal Institute of Technology, Stockholm. It is used for recording locus diagrams of two-terminal and four-terminal networks within the frequency range of 10–500 kc. The meter comprises a signal generator, phase indicators, and a recording instrument. The phase indicators consist of balanced tube-wattmeters.

Two Portable Substandards of Frequency. Renat Terlecki, and J. W. Whitehead. *Journal of Scientific Instruments*, Vol. 25, No. 7, July, 1948, pp. 237–239, figs.

Counting Tubes for the Detection of Radio-Active Rays. Ruediger. (*Friedrich Krupp, AG, EIS Kro/1940/F. v. MHZ*, May 10, 1944.) *U.S., Air Force, Translation No. F-TS-1815-RE (ATI No. 1462)*, July, 1948. 12 pp., diagrs., figs. 6 references.

Spectral Emissivity and Electron Emission Constants of Thoria Cathodes. T. E. Hanley. *Journal of Applied Physics*, Vol. 19, No. 6, June, 1948, pp. 583–589, illus., diagrs., figs. 4 references.

Power Diodes. I—The Design of High Vacuum Oxide-Coated Rectifiers. II—The Manufacture of High Vacuum Oxide-Coated Rectifiers. E. G. Rowe, R. E. B. Wyke, and W. Macrae. *Electronic Engineering*, Vol. 20, Nos. 245, 246, July, August, 1948, pp. 214–218; 254, 255, 258, 259; illus., figs.

Microphonism in a Subminiature Triode. V. W. Cohen and A. Bloom. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 8, August, 1948, *Waves and Electrons Section*, pp. 1039–1048, diagrs., figs.

H. F. Pentodes in Electrometer Circuits. K. D. E. Crawford. *Electronic Engineering*, Vol. 20, No. 245, July, 1948, pp. 227–231, figs. 6 references.

The Telecommunications Industry; Some Metallurgical Problems of Materials and Maintenance. E. Mills. *Sheet Metal Industries*, Vol. 25, No. 225, July, 1948, pp. 1369–1382, figs. Factors influencing choice of materials (space, wear, corrosion), contacts and contact materials (with table of properties of 11 materials), and commonly used metals.

Piezoelectric Ceramics. B. B. Bauer. *Radio & Television News*, Vol. 40, No. 2, August, 1948, *Radio-Electronic Engineering*, pp. 3–5, 28, 29, illus., diagrs., figs. 10 references.

New Alloy Has Improved Electrical Resistance Properties (Evanohm). *Materials & Methods*, Vol. 28, No. 2, August, 1948, pp. 62, 63, figs.

Germanium Rectifiers. *Electronic Engineering*, Vol. 20, No. 245, July, 1948, p. 232, diagr., fig.

Thermoelectric Generator Designs. Grenville B. Ellis. *Electrical Engineering*, Vol. 67, No. 7, July, 1948, pp. 657–660, figs.

Thermo-Electric and Conductive Properties of Blue Titanium Dioxide. H. K. Henisch. *Electrical Communication*, Vol. 25, No. 2, June, 1948, pp. 163–177, illus., diagrs., figs. 30 references.

Nickel-Iron Alloy Dust Cores. S. E. Buckley. *Electrical Communication*, Vol. 25, No. 2, June, 1948, pp. 126–131, illus., figs. 10 references.

Modern Demonstration of MacDonald's Equivalance Theorem. A. G. Clavier. *Electrical Communication*, Vol. 25, No. 2, June, 1948, pp. 148–151, figs. 2 references.

The Application of Matrices to Vacuum-Tube Circuits. J. S. Brown and F. D. Bennett. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 7, July, 1948, pp. 844–852, diagrs. 21 references.

Relationship Between Rate of Transmission of Information, Frequency Bandwidth, and Signal-to-Noise Ratio. C. W. Earp. *Electrical Communication*, Vol. 25, No. 2, June, 1948, pp. 178–195, fig.

New Methods of Filter Design by Means of Frequency Transformations. Gösta Neovius. (*Kungl. Tekniska Högskola, Handlingar Nr. 3*, 1946.) *Acta Polytechnica* (Stockholm), No. 8 (*Electrical Engineering Series*, Vol. 1, No. 2), 1947. 41 pp., figs. Sw. Kr. 2.

Filter design based on methods of frequency transformation of T. Laurent. A tabular transformation procedure is suggested, in addition to the original purely graphical method. The method is illustrated by example of the calculation and design of low-pass, high-pass, and band-pass filters. Attenuation due to losses and reflection is not considered in the examples.

Cathode-Coupled Negative-Resistance Circuit. Peter G. Sulzer. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 8, August, 1948, *Waves and Electrons Section*, pp. 1034–1039, figs. 3 references.

Distributed Amplification. Edward L. Ginzton, William R. Hewlett, John H. Jasberg, and Jerre D. Noe. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 8, August, 1948, pp. 956–969, diagrs., figs. 9 references.

Time Response of an Amplifier of *N* Identical Stages. Eugene F. Grant. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 7, July, 1948, pp. 870, 871 figs. 1 reference.

The response of a many-stage amplifier to a unit step of voltage is to be calculated. From this, the response to rectangular pulses may be inferred. In order to simplify the calculations, it is assumed that the pass band is narrow compared to the center frequency so that a low-pass equivalent circuit may be analyzed, and

its behavior will describe sufficiently accurately the behavior of the amplifier.

D.C. Operated Servo Amplifier. Sidney Wald. *Radio & Television News*, Vol. 40, No. 2, August, 1948, *Radio-Electronic Engineering*, pp. 14, 15, 28, illus., figs. An ordinary vibrator is used to modulate a d.c. error voltage. The resulting a.c. voltage is amplified and controls the driving motor.

A New Approach to Tunable Resonant Circuits for the 300- to 3000-Mc Frequency Range. Frank C. Isely. *Institute of Radio Engineers, Proceedings*, Vol. 36, No. 8, August, 1948, *Waves and Electrons Section*, pp. 1017–1022, figs. 4 references.

The Design of Transductor Circuits. I. (*ASEA Journal*, Vol. 21, No. 1-2, January-February, 1948, pp. 3–20.) *The Engineers' Digest*, Vol. 5, No. 5, July, 1948, pp. 235–238, diagrs., figs.

Improving Circuit Diagrams; The Service's Recommendations to Draughtsmen. L. H. Bainbridge-Bell. *Electronic Engineering*, Vol. 20, No. 244, June, 1948, pp. 175–177, diagrs.

An Ultrasonic Memory Unit for the EDSAC. M. V. Wilkes and W. Renwick. *Electronic Engineering*, Vol. 20, No. 245, July, 1948, pp. 208–213, illus., figs. 4 references.

The Miller Integrator. I. B. H. Briggs. *Electronic Engineering*, Vol. 20, No. 246, August, 1948, pp. 243–247, figs. 2 references.

Radio Repair. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, pp. 82, 83.

Time Function of the Radiation of Short Spark Discharges. Heinz Fischer and Martin Reger. (*U.S., Air Force, Technical Report No. F-TR-1178-ND (GS-USAF Wright-Patterson Air Force Base No. 86)*, May, 1948.) *U.S., Air Force, Air Technical Intelligence, Technical Data Digest*, Vol. 13, No. 13, July 1, 1948, pp. 9–15, illus., figs. 12 references. (*See* AER 10/48:52.)

Airborne Telecasting Proves Successful. *Aero Digest*, Vol. 57 No. 2, August, 1948, pp. 32, 108, illus., diagr.

Equipment

The Aircraft Accessory Manufacturer, The Forgotten Man. J. C. "Cliff" Garrett. *Aero Digest*, Vol. 57, No. 1, July, 1948, pp. 40, 41, illus.

ELECTRICAL (16)

Electrical Units Seen Requiring Special High-Altitude Treatment. Karl Martinez. *SAE Journal*, Vol. 56, No. 7, July, 1948, pp. 24–26. (Extended summary of a paper: Performance of Electrical and Radio Equipment at 40,000 Ft.)

(Martin 2-0-2) Electrical System. *Martin Two-0-Two Design Features*, No. 6, July 15, 1948, pp. 1–3, diagr.

Frequency Converter Performance Calculations. Frederick R. Latzko. *Electrical Engineering*, Vol. 67, No. 7, July, 1948, p. 625, figs.

HYDRAULIC & PNEUMATIC (20)

Research on Aircraft Hydraulic Packings. J. T. McCuistion F. E. Clark, R. A. Clark, and L. E. Cheyney. *SAE Quarterly Transactions*, Vol. 2, No. 2, April, 1948, pp. 227–233, 267, illus., figs. 9 references.

The adoption of petroleum-base hydraulic fluid (specification number AN-VVO-336), O-ring packings, and packing materials developed for low-temperature applications from Perbunan 18 nitrile-type synthetic rubber made it necessary to conduct fundamental research on hydraulic systems and hydraulic packings. From a field survey, the Battelle Memorial Institute made a tentative specification for the properties of a packing and determined those factors beyond the manufacturer's control which affect the lift and function of an O-ring, such as design, loading, materials, and operating conditions. Laboratory tests were undertaken to determine the friction torsional forces to which packings are subjected and to evaluate the effects of standard commercial plasticizers and plasticizers of "octopus" structure on nitrile-type synthetic rubbers. Types of gel and effects of gel on the swelling and processing properties of synthetic rubber stocks, various molding techniques, and the mechanism of spiral failure of O-rings are at present under investigation. Future plans call for cycling tests, stress-aging studies, compounding of packing material, and the action and materials of backing rings.

Why Pneumatics: I—System and Equipment. II—Development and Research. Harvey F. Gerwig and Joseph H. Famme. *Machine Design*, Vol. 20, Nos. 6, 7, June, July, 1948, pp. 116–121; 138–142; illus., diagrs., figs.

I. The pneumatic system used in the Consolidated Vultee XB-46 provides high-speed, heavy-load intermittent operation. By using pressures of from 1,500 to 2,000 lbs. per sq.in. less drain has been placed on the power plant in flight and a reduction in weight over low-pressure pneumatic systems or hydraulic systems has been achieved. Design and operation of the accumulators, compressors, pressure regulators, relief and selector valves, and actuators is treated. II. Graphs and tables comparing the weight and power requirements of electric, hydraulic, and pneumatic actuating systems for retraction of landing gear, operation of bombay doors, and braking show the saving obtained in the Consolidated Vultee XB-46 by installing a pneumatic system with a system pressure of 1,500 lbs. per. sq.in. which provided actuating pressures up to 100 lbs. per sq.in. The principal difficulties encountered were the maintaining of lubrication between rubber seals and cylinder walls, the design of pressure regulators with a low-rate spring and metal-diaphragm relief valves with a high fatigue factor, and the development of methods for snubbing actuating cylinders at the end of their stroke.

New Hydraulic Fluids Won't Burn. *Machine Design*, Vol. 20, No. 7, July, 1948, p. 113, illus.

Water-based hydraulic fluids developed by the Naval Research Laboratory after undergoing 2 years of testing by the Navy are being tested by the C.A.A. for commercial air-line use. The fluids are less corrosive than water, have less deteriorating effect on packing than conventional fluids, freeze at —50°F., and are nonflammable.

Flight Safety & Rescue (15)

Can Chances of Survival be Increased? R. E. Hardingham. *Royal Aeronautical Society, Journal*. Vol. 52, No. 451, July, 1948. pp. 477–480.

An analysis of the fatality and severity of aircraft accidents by type of accident. The consistency of fatalities or degree of severity of injury in the same aircraft design, and recent design studies, show that it is possible to reduce the number of fatalities and degree of severity of injuries by proper design of aircraft interiors. To bring this about, the designer must realize that structural perfection and airworthiness alone cannot eliminate accidents or mitigate their severity.

Safety Belt Function in Crash Protection. *Western Flying*, Vol. 28, No. 6, June, 1948, pp. 14, 20, 22.

An analysis by The Crash Injury Research Project of the National Research Council of crash accidents and measurements of the forces sustained by safety belts during crashes showed that the central portions of the body suffer little damage when held in close relationship with the cabin structure until either the belt or the surrounding cabin structure fails. Similar protection should be provided for the head and upper parts of the body by chest or shoulder harnesses to prevent their impact at full crash velocity with cabin structures that have already stopped.

Quick Release for Safety Belts. *The Aeroplane*, Vol. 74, No. 1933, June 25, 1948, p. 761, diagrs.

A safety-belt attachment fitting consisting of a special "U"-shaped release pin. One leg of the pin retains the belt eye fitting. The other is a spring-loaded piston acting in a cylinder that is an integral part of the fitting. Compressed air raises the piston and, hence, the retaining pin releasing the belt. Both pilot and stewardess have access to controls and can introduce compressed air into the system to release the belts in an emergency.

Bailing Out at High Speed. Russell K. Thaw. *Western Flying*, Vol. 28, No. 8, August, 1948, pp. 11, 12, illus.

Jets Require Extra Ground Safety Promotion. *Plane Facts*, Vol. 5, No. 7, July, 1948, pp. 10, 11, 26, 27, illus., diagrs., fig. Precautions necessary for safe ground handling of jet aircraft.

Australian Aviation's Record: Safety in the Air. *Indian Skyways*, Vol. 2, No. 4, April, 1948, pp. 27–29.

Air Safety in Australia. E. V. E. Neill. *Indian Aviation*, Vol. 32, No. 4, April, 1948, pp. 94, 96.

Pilot Error Still Major Cause of Accidents. *Canadian Aviation*, Vol. 21, No. 7, July, 1948, p. 42, figs. Analysis of civil flying accidents in Canada during 1947.

Actual Accident Experiences Emphasize Air Safety Lessons. *Canadian Aviation*, Vol. 21, No. 8, August, 1948, p. 28, illus.

Who's to Blame for Accidents? *Plane Facts*, Vol. 5, No. 6, June, 1948, pp. 14–16, 28, 29. Summary of a report by R. E. Jones and Paul M. Fitts of the Air Materiel Command, Aero Medical Laboratory.

Crash Probers Cite CO_2 Danger. *Aviation Week*, Vol. 49, No. 1, July 5, 1948, pp. 13, 14.

Airport Fire Control Equipment Survey. G. Silvering. *Airports and Air Carriers*, Vol. 13, No. 6, June, 1948, pp. 13, 14.

A summary and a tabulation of the responses of 59 Class 3 airports and larger and 34 Class 2 airports and smaller. Questions in survey included: types of aircraft using airport; fire-extinguishing equipment on hand and agent used; provision of fire hydrants and adequacy of water supply; distance from municipal fire department; time required to reach crash on, and adjacent to, airfield; equipment that could be used on, and problems presented by, surrounding terrain; and fire brigades and frequency of drills.

Are Present Fire Fighting and Crash Rescue Techniques Adequate? B. R. Chaplin. *Plane Facts*, Vol. 5, No. 7, July, 1948, pp. 7–9, 27, illus. Summary of studies made at the Air Force Proving Grounds, Eglin Field.

Flight Testing (13)

Accuracy of Airspeed Measurements and Flight Calibration Procedures. Wilber B. Huston. *U.S., N.A.C.A., Technical Note No. 1605*, June, 1948. 80 pp., figs. 97 references.

A discussion of all the factors that limit the accuracy with which air speed may be determined by the usual pitot-static methods. The general equations for the air speed and Mach Number in terms of the static and impact pressure and the indicated temperature show the error introduced in the Mach Number, the temperature, and the true air speed by errors in measurement. The results of tests of a number of different pitot-static tubes show the influence of the geometry of the head, angle of attack, Mach Number, Reynolds Number, turbulence, and drain holes on the development of total and static pressures. The magnitude of these pressures is also affected by the field of flow about the body on which the measuring instrument is located and their indication is influenced by the lag in the pressure transmission system and the indicating device. This indication lag, determined experimentally, forms the basis of the correction of flight data. Methods are summarized by which the inherent error of recording and indicating instruments may be corrected, reduced, or eliminated. The temperature data, required in the determination of true air speed, are measured by an instrument that must be corrected and also calibrated. Final corrections must be established by the flight calibration of air-speed and temperature installations.

Accurate Checks Without Calculations. *Aviation Week*, Vol. 49, No. 1, July 5, 1948, pp. 24–26, illus.

Photographs of aircraft landings and take-offs are taken through a grid that is aligned with the 100-ft. divisions of the runway. Visual and radio signals from the aircraft indicate the beginning of the take-off; automatic indicator lights on the landing-gear struts show when they are fully extended and the aircraft is air-borne. A moving metal tape below the grid is calibrated in seconds to provide a time reference. When read with verniers mounted on the grid frame, timing can be obtained which is accurate to within $^1/_{200}$ sec.

100 Kilometres. *Aeronautics*, Vol. 19, No. 1, June, 1948, pp. 70–72, illus. Description of a record flight on the 100-km. closed-circuit course of a de Havilland 108 jet research airplane.

Some Aspects of the 100-km. Closed Circuit Record. *De Havilland Gazette*, No. 45, June, 1948, pp. 6, 7, illus.

Fuels & Lubricants (12)

An Evaluation of Proposed Reference Fuel Scales for Knock Rating. Henry C. Barnett and Thomas C. Clarke. *U.S., N.A.C.A., Technical Note No. 1619*, July, 1948. 56 pp., figs. 3 references.

Reference-fuel combinations proposed for measuring the knocking tendencies of aviation fuels are comparable in temperature sensitivity to typical aviation fuel blends and will extend the range of knock-limited performance of current rating scales by an appreciable amount when used with satisfactory rating engines. On the other hand, difficulties with the occurrence of preignition in the F-4 engine and the severity of operating conditions in the F-3 engine indicate that these two engines in their present form and under present specified operating conditions are inadequate for rating aviation fuels having performance numbers in excess of 161.

Gas Turbine Fuels and Lubricants. H. A. Murray and B. S. Bailey. *Aero Digest*, Vol. 57, No. 1, July, 1948, pp. 58–60, 95, 98, figs. 1 reference.

The wide range of operating conditions of turbojet and turboprop aircraft engines imposes severe requirements on an ideal fuel. Low volatility fuels present no problem of vapor loss and require no booster pumps in the fuel line to prevent vapor lock until the aircraft exceeds an altitude of 55,000 ft. A preliminary starting fuel must be used with low volatility fuels. Their combustion efficiency is poor, and in many cases poor performance at cruising and rated speed is obtained. Some engine designs are sensitive not only to the distillation range but also to the composition of the fuel and burn both paraffinic and naphthenic straight-run fuels more readily than a highly aromatic type made from cracked stocks. Since service tests have shown that range can be increased in almost direct proportion to the heading value of the fuel, it might be advisable to design engines to use aromatic fuels with higher boiling points. The freezing point and viscosity set by specifications limit jet-engine fuels to the kerosene type of fuel, which constitutes only 15 per cent of the crude stock. A proposed new specification with a distillation range of 100° to 600°F. will increase the yield to 55 per cent if cracked stocks can be used. Lubricants must show no tendency to foam or to lose an excessive amount of light ends at the atmospheric pressures met between sea level and 25,000 ft. They must be stable, not oxidize, and permit cold starting from −80° to +160°F. For the turbojet engine a highly refined petroleum with a low pour point has been adopted, while for the turboprop, a standard aircraft-engine oil is used because of the reduction gears based on aircraft gear design. Description of turbojet and turboprop lubricating systems is included.

Fuel Freezing Hazards Studied. Lon Storey, Jr., and J. C. Duffendack. *Aviation Week*, Vol. 48, No. 24, June 14, 1948, pp. 26, 27, 30, 31, illus., figs.

During tests to determine the action of micronic fuel filters with changes in the viscosity of fuel subjected to extreme cold, the high increases in the pressure drop across the filter which were observed were caused by the crystallization of entrained and emulsified water in the fuel and its deposition on the filter element as slush. As little as 0.1 per cent water per 100 gal. of fuel was sufficient at 15°F. to cause the opening of filter by-pass valves. The addition of alcohol to the fuel in quantities approximately equal to the anticipated water content caused sufficient depression of the freezing point to prevent ice precipitation at fuel temperatures down to approximately −40°F.

Knock-Limited Performance of Several Branched Paraffins and Olefins. R. S. Genco and I. L. Drell. *U.S., N.A.C.A., Technical Note No. 1616*, June, 1948. 39 pp., figs. 7 references.

F-3, F-4, and 17.6 engine data for 2,2,3,3,-tetramethylpentane, 2,4-dimethyl-3-ethylpentane, 2,3-dimethylpentane, 2,3-dimethyl-2-pentene, 2,3,4-trimethyl-2-pentene, and 3,4,4-trimethyl-2-pentene, individually blended with several base fuels. These and other high-antiknock-performance hydrocarbons, prepared and tested by the N.A.C.A., are compared for fuel temperature-sensitivity and engine severity. At mild or moderate engine severity, 2,2,3,3-tetramethylpentane blend was highest in knock limit of the paraffins tested, but at severe conditions it was lowest. At severe (F-3) conditions, triptane blend was best.

A Method for Determination of Aromatics in 150° to 300° C. Fractions of Crude Petroleum by Measurement of Aniline-Point Rise. Arthur M. Busch, Alden P. Leaves, and Robert R. Hibbard. *U.S., N.A.C.A., Technical Note No. 1641*, June, 1948. 24 pp., figs. 18 references.

Rise in aniline point, resulting from the removal of aromatics by silica-gel percolation, is a linear function of known aromatic content. Analysis of five cuts of four crudes agreed to within 2 per cent with analyses of the same samples by a different method at another laboratory. Interference by naphthenes has been satisfactorily eliminated.

Qualitative Experimental Verification of the Change of Burning Rate of Rocket Powders with Radiation Path Length. S. S. Penner. *Journal of Applied Physics*, Vol. 19, No. 6, June, 1948, pp. 511–513, figs. 3 references.

Experimental studies on step-machined powder grains indicate a small increase in the average burning rate of solid fuel rocket

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propellants with an increase in the radiation path length. This result is in agreement with theoretical predictions.

Preignition-Limited Performance of Several Fuels. Donald W. Male and John C. Evvard. *U.S., N.A.C.A., Report No. 811*, 1945. 5 pp., figs. 4 references. U.S. Govt. Printing Office, Washington. $0.10.

Knock-Limited Performance of Several Internal Coolants. Donald R. Bellman and John C. Evvard. *U.S., N.A.C.A., Report No. 812*, 1945. 13 pp., diagrs., figs. U.S., Government Printing Office, Washington. $0.15.

Gliders & Gliding (35)

Aluminum Sailplanes. I, II. B. S. Shenstone. *The Aeroplane*, Vol. 74, No. 1932, June 18, 1948, pp. 732–734· Vol. 75, No. 1934, July 2, 1948, pp. 21–23; illus., diagrs., figs.

I. A history of the use of light-metal alloys for the skin and the structural members of sailplanes. Includes dimensions, weights, calculated performance, and wing and fuselage construction for the French all-aluminum sailplane SO-Pl and general characteristics of the Schweizer SGS-1-21. II. Design and construction of the wing, tail, and fuselage of the Schweizer SGS-1-21 all-metal-sailplane. It is compared with the French SO-Pl plane in adaptability to large scale production, weight of components, and estimated performance.

International Gliding Contests; The British Captain Discusses Training, Equipment and Prospects. Ann Douglas. *Flight*, Vol. 54, No. 2063, July 8, 1948, pp. 41–45, illus.

Centre of Gravity Launch; Automatic Safety Release. R. C. Stafford Allen. *Sailplane and Glider*, Vol. 16, No. 7, July, 1948, pp. 7, 8, diagr.

Howgozit for the Channel. J. C. Neilan. *Sailplane and Glider*, Vol. 16, No. 6, June, 1948, pp. 4, 5, figs.

Flying Wing Sailplanes. Don S. Mitchell. *Soaring*, Vol. 12, No. 5-6, May-June, 1948, pp. 8, 9, illus.

Double Tow. Stephen J. Bennis. *Soaring*, Vol. 12, No. 3-4, March-April, 1948, p. 7.

The Air-100 (Jarlaud French Sailplane). *Soaring*, Vol. 12, No. 3-4, March-April, 1948, pp. 2, 3, illus.

Tiny Mite (Designed by R. Parker). Dick Johnson. *Soaring*, Vol. 12, No. 5-6, May-June, 1948, pp. 10, 11, illus.

Midget Glider (P.H. 29 and P.H. 33). F. J. Piatelli. *Soaring*, Vol. 12, No. 5-6, May-June, 1948, pp. 4, 5, 12, illus.

America's 1-21 (Schweizer). Dick Comey. *Soaring*, Vol. 12 No. 5-6, May-June, 1948, pp. 2, 3, 13, 15, illus.

Guided Missiles (1)

Impulse Determinations of Rockets by Means of Rotating Systems. S. S. Penner and R. C. Whiteman. *Review of Scientific Instruments*, Vol. 19, No. 7, July, 1948, pp. 428–435, figs. 7 references.

Two simple rotating systems for the determination of the specific impulse of rocket propellants. One, the pin wheel system, consists of a bicycle wheel mounted horizontally in a steel frame. A small rocket motor containing the propellant to be tested is mounted on the wheel so that the thrust delivered by the rocket accelerates the speed of rotation of the wheel. A photographic record of the rotational speed is then used to calculate the impulse delivered as a function of the time. The other, the rotating-bar system, is operated in a manner similar to that of the pin wheel. The rotating systems have been used for the determination of relative effective gas velocities of a number of double-base rocket powders. Impulse measurements of miniature rockets of the order of 1 lb.-sec. were made. An investigation of the effect of expansion ratio of rocket nozzles on the reduced specific impulse showed good agreement with theoretical calculations.

Initial Arc of the Trajectory of Departure. Derek F. Lawden. *British Interplanetary Society, Journal*, Vol. 7, No. 3, May, 1948, pp. 119–123.

The equations governing the trajectory of departure of a rocket whose jet is maintained parallel to its motion are unsuited to numerical calculation of the initial arc of the trajectory because of the rapid variation of the perpendicular from the center of attraction to the tangent to the trajectory. If, however, the variation in direction and magnitude of the gravitational acceleration is neglected, manageable formulas are obtained which are sufficiently accurate to compute the first 50 miles of a trajectory of departure from the point at which the rocket's thrust is brought into parallelism with its velocity.

Tracking the Rockets; New Telescopes Used to Photograph Flight of Stratospheric Missiles. Martin Mann. *Ordnance*, Vol. 33, No. 169, July-August, 1948, pp. 23–25, illus.

In addition to radar, Bowen-Knapp and ballistic cameras, and refracting telescopes on machine-gun mounts, modified astronomical telescopes and Dovap, and an electronic system employing the Doppler effect, are used at the White Sands rocket-proving ground to track and record the flight path and behavior of rockets. A 16-in. reflecting telescope produces an image of the rocket in flight, magnified as much as 80 times, which is recorded by a standard moving-picture operating at 16 frames per sec. The frames contain time reference pips, a clock dial, and dials indicating azimuth and elevation. The telescope is mounted on a 90-mm. gun. An operator keeps the missile centered in an auxiliary telescope by operating the hydraulic aiming servomechanism of the gun mount. Dovap transmits a continuous signal to a transceiver in the missile itself, which in turn transmits to the ground a signal whose frequency is twice that of the signal it received. The signal from the rocket is heterodyned with a signal whose frequency is twice that of the original signal transmitted. The resulting beats indicate the velocity of the missile.

Guided Missiles. II, III. A. R. Weyl. *The Aeroplane*, Vol. 74, Nos. 1931, 1933, June 11, 25, 1948, pp. 695–698; 757–759· illus., figs.

II. A chronology of the development of controlled, pilotless aircraft and missiles in the U.S., Great Britain, and France from 1918 to 1940 and an account of similar investigations in Germany during, and subsequent to, World War I which laid the foundation for the development of the V-1 flying bomb. Statistics of launchings and hits in Amsterdam and England show the ineffectiveness of the missile as a military weapon. British official and popular reaction to the weapon is commented upon. III. Rocket-propelled guided missiles had their inception in the theoretical and experimental work done by astronavigation enthusiasts in Russia, France, Germany, and the U.S. Because solid-fuel propellants were found to be inefficient and unreliable, liquid-fuel rocket engines were developed.

History & Literature*

Naval Contributions to Aeronautical Science, 1908–1913. Mary C. Welborn. *U.S. Naval Institute, Proceedings*, Vol. 74, No. 546, August, 1948, pp. 990–997, illus.

Instruments (9)

A Device for Measuring Sonic Velocity and Compressor Mach Number. Paul W. Huber and Arthur Kantrowitz. *U.S., N.A.C.A., Technical Note No. 1664*, July, 1948. 12 pp., diagrs., fig. 4 references.

The design, operation, and calibration of an instrument for measuring the velocity of sound in fluids at stagnation and/or determining the Mach Number of a compressor or turbine. A Helmholtz resonator and an earphone are contained in an atmosphere of the fluid to be investigated or in the working fluid of the compressor or turbine at inlet conditions. From a reading of the volume at resonance when the earphone is excited by an alternating current of known frequency or the frequency of the rotating shaft, the velocity of sound or the compressor Mach Number may be measured to an accuracy of better than 0.5 per cent. Calibration of the Helmholtz resonator to include the action of viscosity at the orifice is accomplished by using a parameter that includes the kinematic viscosity of the gas and the frequency of sound in the resonator which is obtained from Stokes' solution of the flow near an oscillating wall.

The Measurement of Free Air Temperature from Aircraft. G. S. Hislop, Ezer Griffiths, and A. R. Challoner. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2229*, November, 1942. 10 pp., illus., diagrs., figs. 1 reference. British Information Services, New York. $0.70.

A multiple-junction thermocouple thermometer with the conjunction enclosed in a pitot fairing gave steady and consistent compression effect calibrations, which, when the fairing was facing forward, were the full theoretical adiabatic correction and, when facing backwards, were about 75 per cent of the theoretical. The cold junction of the multiple thermoelement was maintained

at a constant temperature of 0°C., by immersion in a mixture of ice and water. Using a moving-coil instrument as indicator, the lag of the system was in the order of a few seconds. The accuracy of the air temperature readings was limited only by the steadiness of the flight conditions.

A Two-Phase Voltage-to-Distance Servomechanism. *Electronic Industries*, Vol. 2, No. 6, June, 1948, pp. 12, 13, figs.

Gyroscopes and Their Applications. K. A. Oplinger. *Machine Design*, Vol. 20, No. 7, July, 1948, pp. 101–105, 186, 188, illus., diagrs., figs.

The Analysis of Retarded Control Systems. Louis A. Pipes. *Journal of Applied Physics*, Vol. 19, No. 7, July, 1948, pp. 617–623, figs. 15 references.

The analysis is applicable to general control systems and is based on the solution of a linear differential equation of infinite order. The mathematical investigation is performed by operational methods, and the question of stability is studied by the use of the complex variable.

Tensorial Analysis of Control Systems. Gabriel Kron. *Journal of Applied Mechanics*, Vol. 15, No. 2, June, 1948, pp. 107–124, figs. 5 references.

The resultant equations of a dynamical system such as a servomechanism is established by removing all interconnections between the various amplification stages and finding the impedance matrix of each isolated stage. The effect of their interconnection is represented by a matrix of transformation. The impedance matrix of the resultant system can be found without any physical analysis by a simple routine matrix manipulation involving the impedance matrix, the transformation matrix and its partial derivatives, and the steady-state force vector.

Application of the Performance Operator to Aircraft Automatic Control. Robert C. Seamans, Jr., Benjamin G. Bromberg, and L. E. Payne. *Journal of the Aeronautical Sciences*, Vol. 15, No. 9, September, 1948, pp. 535–555, illus., figs. 20 references.

The performance operator is a mathematical concept that expresses the relationship between the output of a control system and the actual input or forcing function responsible for the output. The performance operator of a system comprising any number of operating components can be related to the component operators through straightforward algebraic processes. Since in aircraft automatic-control systems both the input and the output are vector quantities, a vector performance operator is developed by which the response of a linear component or system to all periodic functions can be obtained, thus permitting use of the Nyquist criterion for determining or modifying a control system. The performance operators of the components can be computed mathematically from the performance equations. The system performance operator can be determined without a knowledge of the individual stability derivatives when flight-test data are used. Such experimental determinations can be accomplished by the application of a simple harmonic of step input and measurement of the resultant output. The basic steps to be followed in designing a specific multiloop system are summarized, and their application is illustrated in the design of a typical longitudinal control system.

Stabilization of Carrier-Frequency Servomechanisms. I—Gain-Phase Margin Diagrams of Controller Characteristics. Andrew Sobczyk. *Franklin Institute, Journal*, Vol. 246, No. 1, July, 1948, pp. 21–43, figs. 4 references.

An analysis of linear carrier-frequency systems which shows that the stability and fidelity of the output with respect to the input of electrical servomechanisms using a two-phase alternating-current control motor depends on the characteristics of a controller-demodulator unit in which the motor is incorporated. By calculating the steady-state effect of a linear transfer characteristic on the suppressed-carrier modulated error signal, transformed Nyquist diagrams in which the gain is plotted against the phase margin can be used as a criterion of stability. A series of such diagrams shows the effect of the correctly tuned band-rejection network, the effect of band width of the network being tuned off the carrier frequency, the effect of increasing gain or velocity constant, and the effect of using phase-shifting networks. Since the method does not require symmetry of the characteristics about the carrier frequency, a band-rejection network tuned to the carrier frequency has an approximate proportional plus derivative action on the envelope of the error signal, resulting in an "anti-hunt" or stabilizing effect similar to a translated band-rejection characteristic (center at zero-frequency) in a corresponding d.c. servo.

Altimeter Lag in Simulated Dives and Climbs. *U.S., National Bureau of Standards, Technical News Bulletin*, Vol. 32, No. 8, August, 1948, pp. 97–99, diagr. 1 reference.

WITAN: A Wind-Time Analyzer. P. E. Kraght. *American Meteorological Society, Bulletin*, Vol. 29, No. 5, May, 1948, pp. 207–218, figs.

The construction of a nomogram that can be used to obtain simply and rapidly wind-time analyses of flight weather problems. The geostrophic wind equation is developed into a geostrophic-wind scale, a displacement scale, a ground speed calculator, and a flying time computer, all combined in a single instrument. It solves problems of geostrophic winds, wind components, advection components, advection distance, cross- and on-route components, ground speed, and flying time between check points. When polar parameters are given, it enables the comparison of great circle and other tracks under specified wind conditions.

Divided Flow, Low-Temperature Humidity Test Apparatus. Arnold Wexler. *U.S., National Bureau of Standards, Journal of Research*, Vol. 40, No. 6, June, 1948, pp. 479–486, diagrs., figs. Available also as *Research Paper No. RP1894*. U.S. Govt. Printing Office, Washington. $0.10.

Operation and Care of Circular-Scale Instruments. James Spencer. *Instruments*, Vol. 21, No. 7, July, 1948, pp. 620–624, 626, 628, 630, 632, illus., figs.

Developments in the Correction of (Marine) Magnetic Compasses. G. N. Harvey. *The Engineer*, Vol. 186, No. 4826, July 23, 1948, pp. 94, 95, figs.

Making Small Apertures (Less than 0.001 In.) in Metal Plates. H. E. Holman. *Electronic Engineering*, Vol. 20, No. 244, June, 1948, p. 186, diagrs.

Nonmetallic Diaphragms; Their Design and Application. J. H. Swartz. *Machine Design*, Vol. 20, No. 6, June, 1948, pp. 153–158, 206, illus., figs. Chemical and physical properties, design, and mounting of thrust-multiplying and differential-pressure nonmetalic diaphragms; five typical applications are illustrated.

Designing Instrument Dials for Quick, Accurate Reading. Walter F. Grether. *Machine Design*, Vol. 20, No. 6, June, 1948, pp. 150–152, 208, 209, illus., figs. (Extended summary of a paper.)

Research on Flow Nozzles by the A.S.M.E. Special Research Committee on Fluid Meters. S. R. Beitler and H. S. Bean. *Ohio,*

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State University, Engineering Experiment Station, Bulletin No. 131, May, 1948. 150 pp., figs., tables. $1.00.

Laboratories, Aeronautical (50)

Microtime Instrumentation Featured at Navy's New Michelson Laboratory. *Instruments*, Vol. 21, No. 6, June, 1948, pp. 542, 543, illus.

Research Revelation; Exhibition of Current Activities at the National Physical Laboratory. *Flight*, Vol. 54, No. 2062, July 1, 1948, pp. 20, 21, illus.

Commonwealth Research; Co-Operative Attack on Fundamental Problems. *Flight*, Vol. 54, No. 2063, July 8, 1948, p. 52.

Research in Canada for National Defence. H. M. Barrett. *Engineering Journal*, Vol. 31, No. 5, May, 1948, pp. 271–274.

Laws & Regulations (44)

Convention on the International Recognition of Rights in Aircraft, Signed At Geneva, June 19, 1948. *Journal of Air Law and Commerce*, Vol. 15, No. 3, Summer, 1948, pp. 348–353.

Practical Value of an Appeal Under Section 1006(e) of the Civil Aeronautics Act. Robert F. Daily. *Journal of Air Law and Commerce*, Vol. 15, No. 3, Summer, 1948, pp. 365–369.

Aviation Legislative Report. *Western Flying*, Vol. 28, No. 8, August, 1948, pp. 18, 19. The status of aviation legislation of the 89th Congress.

The Effect of Tariff Provisions Filed Under the Civil Aeronautics Act. D. W. Markham and Drury H. Blair. *Journal of Air Law and Commerce*, Vol. 15, No. 3, Summer, 1948, pp. 251–294.

Courts Now Deem Airports Necessary. Alfred L. Wolf. *Journal of Air Law and Commerce*, Vol 15, No. 3, Summer, 1948, pp. 303–306.

Trends in State Aviation Legislation. U.S., Civil Aeronautics Administration, Office of General Counsel. *Journal of Air Law and Commerce*, Vol. 15, No. 3, Summer, 1948, pp. 331–336.

NASAO Activities. Madeline C. Dinu. *Journal of Air Law and Commerce*, Vol. 15, No. 3, Summer, 1948, pp. 325–330.

Patents and the Engineer. II. H. A. Toulmin, Jr. *Product Engineering*, Vol. 19, No. 7, July, 1948, pp. 113, illus. Sale and rental of patent rights, patent ownership, stimulation of invention by employees, special types of inventions, foreign patent protection, and classification of patents.

Machine Elements (14)

Dynamic Capacity of Rolling Bearings. G. Lundberg and A. Palmgren. (*Ingeniörsvetenskapsakademi, Handlingar Nr. 196*, 1947.) *Acta Polytechnica* (Stockholm), No. 7 (*Mechanical Engineering Series*, Vol. 1, No. 3), 1947. 50 pp., diagrs., figs. 10 references. Sw. Kr. 5.

The classical theory of strength cannot satisfactorily explain fatigue of materials at intense stress concentrations, and earlier efforts to find a general theory for the dynamic capacity of rolling bearings have not been successful. The foundation is laid for a statistical theory of fatigue, considering the dispersion in strength of material and the dependence of the strength of a volume element in the depth below surface. In this way a general theory is developed for the dynamic capacity of different types of rolling bearings and for equivalent radial and thrust loads under different loading and running conditions. The theory agrees with tests run at SKF.

The Hydrosphere—A New Hydrodynamic Bearing. M. C. Shaw and C. D. Strang, Jr. *Journal of Applied Mechanics*, Vol. 15, No. 2, June, 1948, pp. 137–145, figs. 12 references.

When the Reynolds differential equation is written with respect to coordinates along and perpendicular to a mean streamline, it is apparent that an oil wedge normal to the direction of motion may produce positive pressure, provided that there is flow of the lubricant normal to the direction of motion. Hydrodynamic pressure may therefore be produced in a bearing by any forces that tend to increase the flow in a direction perpendicular to the direction of motion of the bearing element so as to alter the path of a mean streamline (e.g., centrifugal inertia force); by factors, such as the geometry of the bearing, which cause the mean streamlines to coverage; by changes in density due to pressure changes in the oil film; and by an oil wedge normal to the direction of motion of the bearing element. Tests made with spherical thrust bearings, hydrospheres, confirmed this theory and showed that a positive pressure is built up on the upper half of the bearing surface and that the performance improves as the speed increases.

The Bevel Differential; An Operational Analysis. George H. Logan. *Aero Digest*, Vol. 56, No. 6, June, 1948, pp. 47, 49, figs.

Expressions are developed for the angular velocity of a pinion meshed between two racks in terms of the instantaneous velocity of the racks. When extended to the bevel differential, they show that whether the inputs are rates or displacements, positive or negative, the bevel differential automatically indicates one-half of the algebraic sum of the inputs.

Formulas for Involute Curve Layouts. Allan H. Candee. *Product Engineering*, Vol 14, No. 8, August, 1948, p. 145, figs.

High Accuracy Contour Cams. R. O. Yavne. *Product Engineering*, Vol. 14, No. 8, August, 1948, pp. 134–136, figs.

Determining Moment of Inertia. Charles E. Crede. *Machine Design*, Vol. 20, No. 8, August, 1948, p. 138, fig.

Backlash Considerations When Designing Gears. Louis D. Martin. *Product Engineering*, Vol. 19, No. 7, July, 1948, pp. 108–110, figs.

Identification Markings of Bolts (AN, NAS, and Contractors' Requirements). *Plane Facts*, Vol. 5, No. 6, June, 1948, pp. 24, 25, 32, illus.

Lubrication Phenomena; Use of Transparent Models for Purposes of Demonstration and Study. John Boyd. *Mechanical Engineering*, Vol. 70, No. 7, July, 1948, pp. 589–592, illus., figs. 4 references.

Maintenance (25)

Stratocruiser Maintenance Access Provisions. *Boeing Service Guide*, No. 10, July, 1948, pp. 10–14, illus.

Lubrication of Main Landing Gear Actuator Governor Plates, with Actuatcr Installed. *Boeing Service Guide*, No. 10, July, 1948, p. 15, illus.

Classified Repair Stations. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, pp. 73–80, diagrs.

Proposed changes in repair station requirements and charts and diagrams showing layout and necessary equipment for typical large, medium, and small air-frame repair stations and typical overhaul shops for large and small engines.

Job Cost Estimating. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, p. 81.

New Plane Cleaner Cuts Man-Hours (Developed by T.W.A.). *Aviation Week*, Vol. 48, No. 25, June 21, 1948, p. 27.

Check List for Users of Solvents. *Canadian Aviation*, Vol. 21, No. 8, August, 1948, p. 43, illus.

Douglas Service, Vol. 6, No. 8, August, 1948. 20 pp., illus., diagrs., figs. Contents: DC-6 Automatic Pilot—General Inspection and Functional Ground Check of Sperry A-12 Gyropilot, DC-6. Thermal Expansion Relief Valves—Addition of Valves in Landing Gear and Wing Flap Hydraulic Systems, DC-3. Plastic Handles, DC-6. Cabin Attendant's Control Panel—Manual Control of Cabin Air Temperature, DC-6. DC-4 Hydraulic System. Storage of Aircraft—Requirements for Seven-Day, Seven-to-Thirty Day and Thirty-to-Sixty-Day Storage Periods, General. Lubrication Charts, General. Cowl Flap Circuit—Resetting of Micropositioners and Power Unit Adjustment, DC-6. Propeller Feathering Procedure—Curtiss Electric and Hamilton Standard, DC-6. Service Hints—Cabin Supercharger Drive Shaft; Cowl Flap Rub Strip, DC-6. Wing Flap Linkage Fairings—Clearance Between Linkage and Fairing, DC-6.

Douglas Service, Vol. 6, No. 7, July, 1948. 20 pp., illus., diagrs., figs. Contents: Heater Temperature Control Switches—Construction, Operation, and Replacement of Adjusting Sleeve, DC-6. Fuel Strainer Line—Redesigned to Permit Easy Removal, DC-6. Flight Controls Rigging—Instructions for Checking Throw, DC-4. Cabin Pressure Control Dehydrators—Refillable Cartridge, Check, and Inspection, DC-6. Shock Strut Servicing, DC-6. Hydraulic System, DC-6 Cabin Supercharger Records—New Serial Number Placard and New Log Card, DC-6. Empennage Attach Fittings, DC-4. Wing Tip Light Rod—New Rigid Attachment, DC-6. "B" Nuts, Lines, and Fittings—Correct Installation and Torquing, General. Fuel Tank Sealing—Recommended Tank Sealants, DC-4, DC-6. Rudder Trim Tab Boot—Safetying and Proper Trimming Procedures, DC-4, DC-6.

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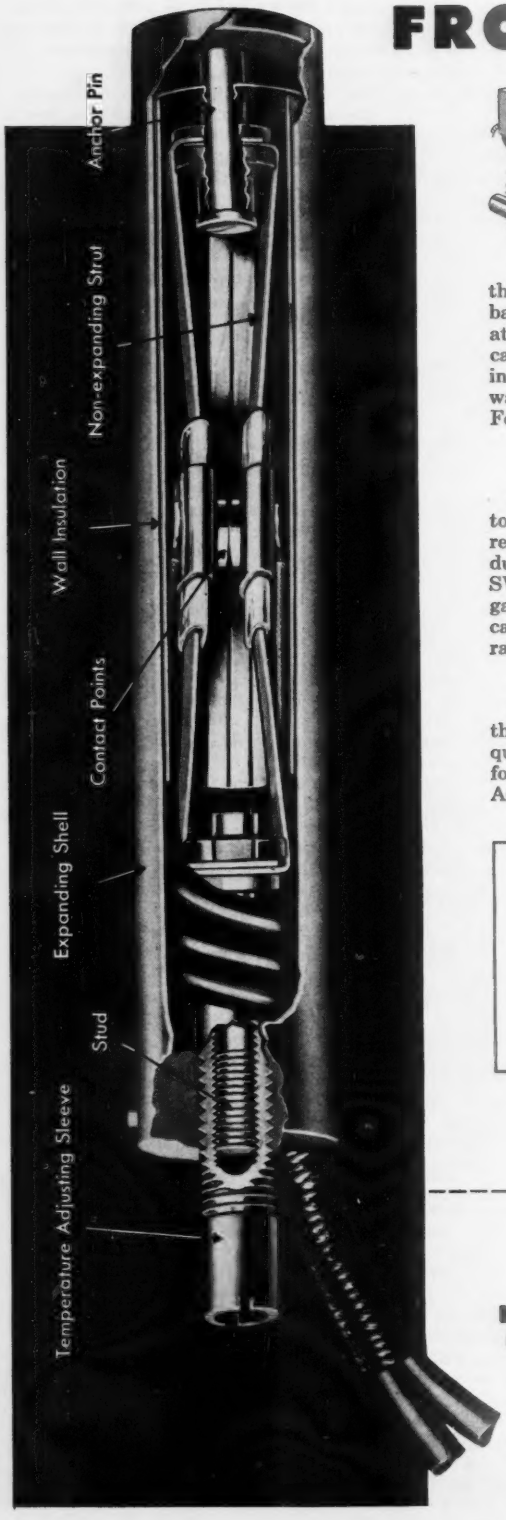

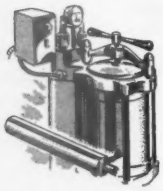

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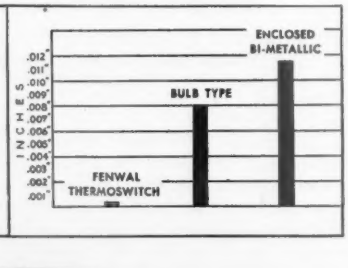

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Specialized Maintenance for the Big Ones (Lockheed Aircraft Service, Inc.). Ira F. Angstadt. *Aero. Digest*, Vol. 57, No. 1, July, 1948, pp. 44, 45, 114, 116, 117, illus.

"Push Button" Dock (United Air Lines Maintenance Base at San Francisco). *Airports and Air Carriers*, Vol. 14, No. 1, July, 1948, pp. 18, 19, illus.

New UAL Base Largely Automatized. *Instruments*, Vol. 21, No. 7, July, 1948, pp. 634, 635, illus.

Production Line Repair Keeps Military Planes Flying. Alan Boyce. *Plane Facts*, Vol. 5, No. 7, July, 1948, pp. 16, 17, 27, illus. Short-cut maintenance methods at Warner Robins Air Force Base.

Management & Finance (45)

Job Evaluation; Assessment for Fair Wage-Payment in Works and Office. J. J. Gracie. *Aircraft Production*, Vol. 10, No. 118, August, 1948, pp. 278–281, figs., tables.

Aviation Common-Stock Holdings. Henry A. Long. *Aero Digest*, Vol. 57, No. 2, August, 1948, pp. 28–30, tables.

Accessory Sales. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, pp. 86, 87, illus.

Inventory Control. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, pp. 88–90, figs.

Airplane Sales. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, pp. 84, 85. Prospect lists and follow-ups.

Materials (8)

The Electron Microscope and Its Application to Materials Problems. J. I. Wittebort. *U.S., Air Force, Air Technical Intelligence, Technical Data Digest*, Vol. 13, No. 12, June 15, 1948, pp. 9–20, illus., figs. 5 references.

A brief discussion of the principles, design, and application of the electron microscope. A collimated electron beam is passed through a specimen and is focused and projected by magnetic or electrostatic lenses to produce a resolution of less than 3 $m\mu$. If the specimen material can be mounted on a $\frac{1}{8}$-in. diameter 200-mesh screen as an electron transparent film less than 1 μ thick, it may be examined directly. Surface structure may be investigated by producing a negative of the surface in a structureless substance and, subsequently, casting a replica of the surface as a thin silicon-dioxide or metal film. Typical electron micrographs illustrate the use of the instrument in determining the size and shape of finely divided matter and aggregates, in revealing the details of surface finishes, and in the identification of microquantities of crystalline materials from their characteristic diffraction patterns.

Non-Destructive Test Methods; Seven Basic Methods for Non-Destructive Testing of Materials. Benson Carlin. *Product Engineering*, Vol. 19, No. 7, July, 1948, pp. 129–132, figs.

METALS & ALLOYS

Properties of Metals at Stratospheric Heights. *Aircraft Engineering*, Vol. 20, No. 233, July, 1948, pp. 207–214, figs. 24 references.

An analysis of available experimental data and theoretical explanations of the physical behavior of aircraft metallic materials such as aluminum, copper, iron, nickel, zinc, wrought aluminum alloys, carbon steels, nickel-chromium steel alloys, and magnesium alloys under the atmospheric conditions that exist in the stratosphere. This is assumed to be an altitude of 18,000 ft. with mean temperature of −56.6°C., air pressure of 57 mm., and humidity of 0.001 per cent by weight. Corrosion and corrosion fatigue are less likely to take place in the stratosphere than at ground level because of the low humidity, density, and temperature. In general, the low temperatures will cause the elastic moduli and the ultimate and yield strengths of metallic materials to increase. The limiting fatigue stress of structural alloys will not be reduced, and for some age-hardening alloys it will be increased. The notched-bar impact value of face-centered cubic-lattice materials will be increased slightly, but, at an unpredictable temperature within the stratospheric range, alloys having other lattice arrangements, such as iron and the carbon steels, will display a suddenly decreased value. In most materials changes in physical properties will be completely reversible.

Theory of Plastic Flow Versus Theory of Plastic Deformation. W. Prager. *Journal of Applied Physics*, Vol. 19, No. 6, June, 1948, pp. 540–543. 11 references.

The concept of neutral change of stress is introduced after a discussion of typical theories of plastic flow and plastic deformation. Since a neutral change of stress can be considered as a limiting case of either loading or unloading, it seems reasonable to demand that the stress-strain relations for both loading and unloading should predict the same change of strain when applied to a neutral change of stress. This condition is satisfied by the theories of plastic flow but not by the theories of plastic deformation.

Hyperbolic Column Formulas for Magnesium-Alloy Extrusions. E. H. Schuette. *Journal of the Aeronautical Sciences*, Vol. 15, No. 9, September, 1948, pp. 523–529, figs. 4 references.

In order to obtain adequate data from which to predict the behavior of simple magnesium-alloy extrusions beyond the elastic range, 89 Z-section columns of M, FS-1, J-1, O-1, and O-1HTA alloys were tested in the 30,000-lb. range of a 300,000-lb. capacity testing machine. Formulas were obtained for the various alloys that gave excellent fits to the test data in the short-column range and are recommended for the design of shapes. It was also observed that the tangent-modulus column curve did not give consistently good fits to test data for magnesium-alloy extrusions, that the end fixity achieved by a column tested flat ended is probably influenced by the cross-sectional shape of the column, and that rounds and shapes follow qualitatively different column curves.

Magnesium as Weight Saver. *Aviation Week*, Vol. 49, No. 2, July 12, 1948, pp. 21, 22, 24, 25, illus.

The use of magnesium alloy in the Consolidated Vultee B-36 bomber is cited to illustrate the saving in weight that can be obtained, the method of processing the alloy, and the limitations of its application. Magnesium alloy constitutes 10 per cent of the air frame by weight, and the weight saved by its use gives an increase in range of 190 miles over alternate designs.

New Magnesium Alloys Offer Superior Properties. Kenneth Rose. *Materials & Methods*, Vol. 28, No. 1, July, 1948, pp. 66–69, illus.

Magnesium alloys containing zirconium (ZK-60 and ZK-60A) display compressive-yield values between 34,000 and 38,000 lbs. per sq.in., in addition to high impact strength. The improved high-temperature characteristics that are obtained with magnesium alloys (such as EM 51), which contain cerium, extend their working range by 300°F. Their creep strength at 600°F. equals that of aluminum alloys.

Investigation of the Validity of an Ideal Theory of Elasto-Plasticity for Wrought Aluminum Alloys. E. G. Thomsen, I. Cornet, I. Lotze, and J. E. Dorn. *U.S., N.A.C.A., Technical Note No. 1552*, July, 1948. 47 pp., figs. 12 references.

The primary purpose was to determine the relation between stresses and plastic strains of wrought aluminum alloys for three types of loading, tension, compression, and torsion. A secondary objective was to identify which assumptions of an ideal theory of elastoplasticity are invalid for these alloys. Universal stress-strain curves as predicted by the theory were not obtained with wrought aluminum alloys. Fair correlation between the theory and experimental facts, however, was obtained with a cast and solution heat-treated R magnesium alloy. Correlation with some of the aluminum alloys was obtained for the compression and torsion data when shear stresses were plotted as functions of effective strain.

Fracture Strength of 75S-T Aluminum Alloy Under Combined Stress. E. G. Thomsen, I. Lotze, and J. E. Dorn. *U.S., N.A.C.A., Technical Note No. 1551*, July, 1948. 30 pp., figs. 13 references.

The effect of combined stresses on the fracture strength of 75S-T aluminum alloy was determined by applying axial loads and internal pressure to thin-wall drawn tubes. Tubular extrusions of 75S-T aluminum alloy rupture in substantial agreement with the critical shear-stress law for fracture. Values of the shear stress for fracture are greater when the macroscopic plane of fracture cuts the lines of fibering than they are when the plane of fracture is parallel to the directions of maximum principal extension during fabrication. As the mean hydrostatic tension increases, the critical shear stress for fracture appears to decrease.

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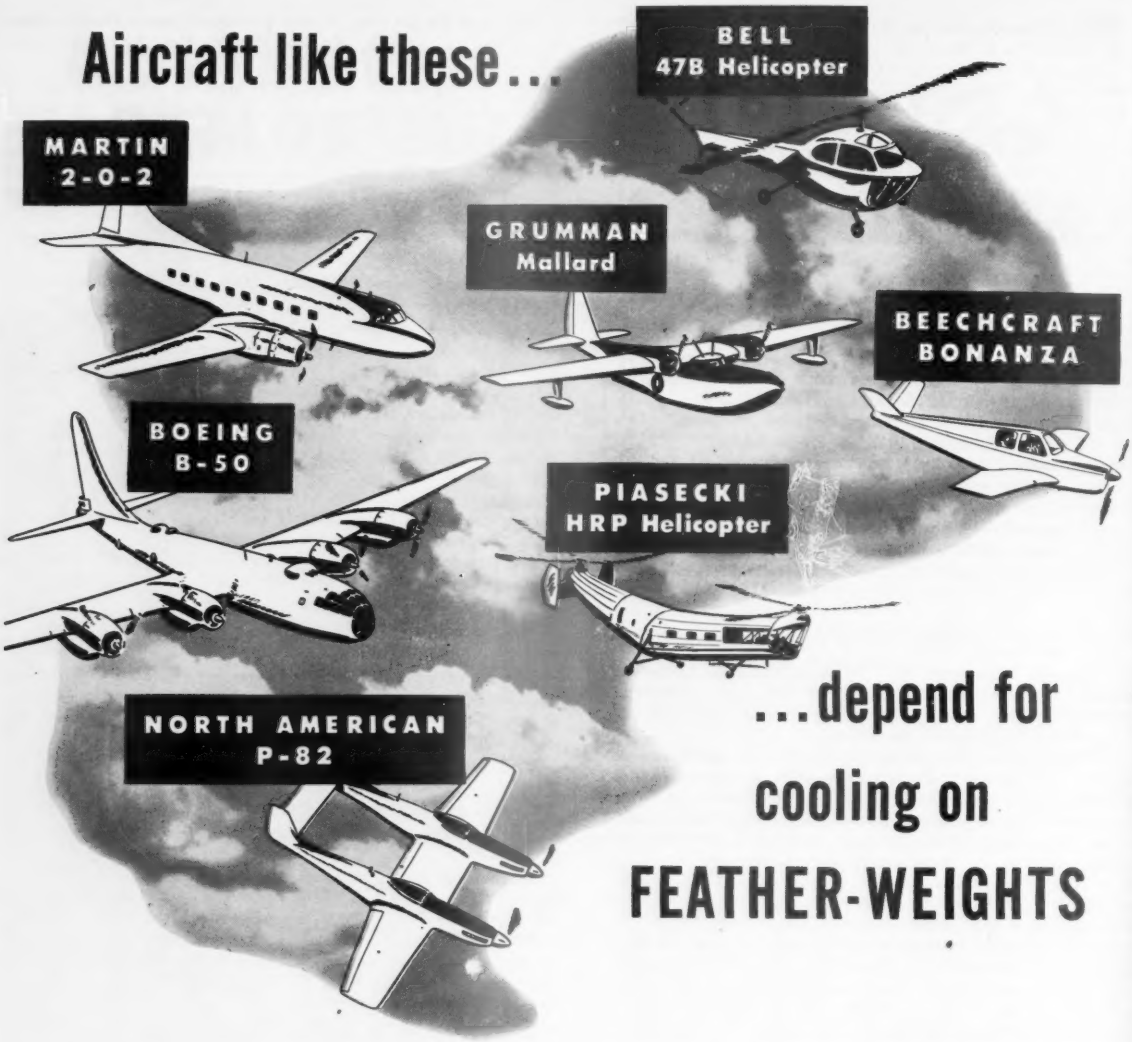

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HYDRAULICALLY-FORMED BELLOWS

Bearing Tests of 14S Sheet and Plate. R. L. Moore. *U.S., N.A.C.A., Technical Note No. 1502,* August, 1948. 18 pp., illus., figs. 6 references

Tests were made to determine bearing yield and ultimate strengths of bare and Alclad 14S-W and 14S-T sheet and plate in thicknesses of 0.064, 0.250, and 0.750 in. The ratios of bearing to tensile properties for the with-grain direction were essentially the same as proposed in *N.A.C.A. Technical Notes Nos. 901, 920, 974, and 981* for other high-strength aluminum alloy sheet and plate.

Bearing Strengths of Some Aluminum-Alloy Sand Castings. R. L. Moore. *U.S., N.A.C.A., Technical Note No. 1523,* August, 1948. 19 pp., illus., figs. 2 references.

Bearing tests were made of aluminum-alloy sand castings of 195-T4, 195-T6, 220-T4, and 356-T6 to evaluate the bearing strength of these alloys and their relation to tensile properties. Bearing-strength characteristics with respect to edge distance and ratios of specimen width to pin diameter were not significantly different from those observed for common wrought-aluminum alloys. Ratios of bearing yield to tensile yield strengths for the castings were about 20 per cent higher than those for wrought materials; ratios of bearing ultimate to tensile ultimate strengths were about the same. Ratios of bearing to tensile strengths are proposed on a basis for selection of allowable bearing values for the design of aluminum-alloy sand castings.

Effects of Overheating Aluminum Determined by Color of Coating. P. A. Haythorne and H. B. Wiley. *Product Engineering,* Vol. 19, No. 7, July, 1948, pp. 104, 105, figs.

The Lockheed Metallurgical Research Laboratories have prepared a set of comparison samples to show the color changes and the deterioration that takes place in yellow zinc chromate primer and zinc chromate primer pigmented to dark green color upon exposure to various temperatures between 300° to 600°F. for periods of time from 5 min. to 12 hours. A correlation has been made of the variations in strength and microstructure of 24S-T Alclad sheet with the color changes of the paint coating which makes it possible to determine without destructive testing the serviceability of an aircraft structural element after accidental exposure to heat.

Handling, Storing and Transporting Wrought Aluminum Alloys. *The Technical Instructor,* Vol. 3, No. 7, July, 1948, pp. 11–16.

A Study of Ceramic Coatings for High-Temperature Protection of Molybdenum. D. G. Moore, L. H. Bolz, and W. N. Harrison. *U.S., N.A.C.A., Technical Note No. 1629,* July, 1948. 31 pp., illus., figs. 4 references.

Refractory ceramic coatings with appropriate coefficients of thermal expansion were developed to prevent the oxidation of molybdenum at high temperatures. The base of the coating was a commercial glass with zirconium-oxide and Florida kaolin additives. The cover coat was a slip of calcined kaolin and zirconium oxide with raw kaolin binder. Up to 1,800°F. no oxidation of the coated specimens was observed after heating for 70 hours. At temperatures above 2,600°F. blistering of the coating was observed. This possibly was due to the evolution of gas absorbed in the metal. The blistering reduced the protection afforded by the coating to a period of 10 to 45 min.

X-Ray Diffraction Investigation of Minor Phases of 20 High-Temperature Alloys. B. M. Rosenbaum. *U.S., N.A.C.A., Technical Note. 1580,* July, 1948. 28 pp., tables. 12 references.

An investigation of minor phases present in 20 high-temperature alloys resulted in identification of seven minor phases: columbium carbide, columbium nitride, titanium nitride, chromium carbide (Cr_7C_3), and carbides of the $M_{23}C_6$ and M_6C types (in which the ratio of metal to carbon atoms is 23:6 and 6:1, respectively). Columbium and titanium were effective nitride and carbide formers. When neither titanium nor columbium was present and chromium was present in the order of 20 per cent in these alloys, the minor phase identified changed from Cr_7C_3 to $M_{23}C_6$ to M_6C as the ratio of the molydenum-plus-tungsten content to the carbon content increased.

A Metallurgical Investigation of Five Forged Gas-Turbine Discs of Timken Alloy. J. W. Freeman, E. E. Reynolds, and A. E. White. *U.S., N.A.C.A., Technical Note No. 1531,* June, 1948. 55 pp., illus., figs. 5 references.

Results of tests to determine the properties at room temperature and 1,200°F. of five gas-turbine discs of Timken alloy show that the discs, which are hot-cold-worked after hot-forging and made from different heats by different companies, will have similar properties. Properties are lower than those of similarly processed bar stock on the basis of tensile and rupture characteristics. Comparison on the basis of rupture strengths showed the Timken discs to be better than a CSA alloy disc, similar to a 19-9DL disc, but not so good as a low-carbon N-155 alloy disc.

Influence of Crystal Plane and Surrounding Atmosphere on Some Types of Friction and Wear Between Metals. Allan T. Gwathmey, Henry Leidheiser, Jr., and G. Pedro Smith. *U.S., N.A.C.A., Technical Note No. 1461,* June, 1948. 37 pp., figs. 9 references.

The coefficient of friction between the (100) faces of two single copper crystals from the surface of which all oxide had been removed was greater than 100, while that between the (111) faces was approximately 25. This difference is attributed to the digging-in and the greater area of contact with (100) faces. The strength of adhesion between two crystals placed in contact, as determined from the area of contact and the vertical pull required to disengage the crystals, was roughly equal to the tensile strength of bulk copper. The influence of the surrounding atmosphere on wear between two polycrystalline copper surfaces was determined by measuring the time required for a copper sphere to wear through a film of copper deposited on a cylindrical steel rotor. In an atmosphere of hydrogen at 300°C., about 10 sec. were required, while in an atmosphere of nitrogen containing 0.2 per cent oxygen, 90 min. were required. The time required for the (110) face, which had been made very rough by etching in stearic acid at 185°C., to wear through a lead film in mineral oil at room temperature was 200 times faster than that taken by the (111) face, which remained smooth after etching. In an atmosphere of hydrogen a polished copper sphere in mineral oil at room temperature wore through a lead film approximately 200 times faster than in an atmosphere of air. The recrystallization of the surface of a single copper crystal upon quenching from a high temperature varied greatly with plane. The metal in the (100) region recrystallized into many crystals to a great depth.

Influence of Crystal Plane and Surrounding Atmosphere on Chemical Activities of Single Crystals of Metals. Allan T. Gwathmey, Henry Leidheiser, Jr., and G. Pedro Smith. *U.S., N.A.C.A., Technical Note No. 1460,* June, 1948. 67 pp., illus. 45 references.

Results of tests to study the influence of crystal plane of single crystals of 13 metals on rates of chemical processes important to the operation or manufacture of lubricated surfaces. These processes are: oxidation in air, corrosion by oils, wetting of the surface by stearic acid with copper, nickel, and iron, rearrangement and roughening of the surface due to the action of hot gases, and electrochemical processes including deposition, etching, replacement, and in a few cases, galvanic action. The results, in general, show the process rates to vary with plane in different degrees, with greater differences between the chemical behavior of two planes of the same metal than between polycrystalline surfaces on two different metals being shown in some cases.

Bearing Metals. H. R. Clauser. *Materials & Methods,* Vol. 28, No. 2, August, 1948, pp. 75–86, illus., figs.

Frictional Properties of Lead-Base and Tin-Base Bearing Alloys: Role of the Matrix and the Hard Particles. D. Tabor. (*Australia, Council for Scientific and Industrial Research, Bulletin No. 212,* 1947.) *The Engineer,* Vol. 186, No. 4827, July 30, 1948, pp. 117–119, illus.

The Extrusion of Plastic Sheet Through Frictionless Rollers. G. F. Carrier. *Quarterly of Applied Mathematics,* Vol. 6, No. 2, July, 1948, pp. 186–192, figs. 6 references.

An Investigation into the Adhesion of Paint to Metal Surfaces. S. C. Britton. *Sheet Metal Industries,* Vol. 25, No. 254, June, 1948, pp. 1185–1190, 1194, illus., diagrs., figs.

A length of stripping lacquer pulled from a surface by a weight hung from its end peels with uniform speed. The weight required to produce movement visible to the unaided eye is taken as a measure of the adhesion between the surface and the lacquer.

A Combined Creep Machine and X-Ray Spectrometer. H. J. Tapsell, H. V. Pollard, and W. A. Wood. *Journal of Scientific Instruments,* Vol. 25, No. 6, June, 1948, pp. 198, 199, illus., diagrs.

In order to study the relation at elevated temperatures of the creep behavior of metals to their x-ray structure, x-ray

examination is made periodically during the application of stress. Accurate tensile loading up to ½ ton, constant throughout the period of uniform yield, can be applied over the gage length of the specimen. The specimen may be set at angles up to 40° from normal incidence to the x-ray beam while maintaining constant distance from 7 to 14 cm. between the film and any desired point on the surface. To spread the reflection spots into a continuous band, the specimen may be oscillated about its horizontal axis. The film cassette can also be oscillated in its own plane about its center.

The Thermal Etching of Silver. B. Chalmers, R. King, and R. Shuttleworth. *Royal Society of London, Proceedings, Series A*, Vol. 193, No. 1035, July 21, 1948, pp. 465–483, 4 pp. of illus., diagrs. 40 references.

Permanent Mold Castings—Ferrous and Nonferrous. Herbert Chase. *Materials & Methods*, Vol. 28, No. 1, July, 1948, pp. 75–86, illus., tables.

Unappreciated Advantages of Modern Gray Iron. Frederick G. Sefing. *Mechanical Engineering*, Vol. 70, No. 8, August, 1948, pp. 667–670, 674, figs.

A Survey of Established Processes for the Jointing of Metals. (II—Redux Bonding Process.) D. F. Hewitt. *Sheet Metal Industries*, Vol. 25, No. 225, July, 1948, pp. 1,399, 1,400, fig.

Plastic bonding of metals is desirable where surface smoothness and distortion from heating effects are to be avoided or an electrical insulating film is required between the metals of the joint. Preparation of metal surfaces, application of the adhesive, heating, and curing the joint are described. In some cases the bonding gives greater strength than spot welding or riveting in similar junctures.

Tests on Redux-Bonded Panels. *The Aeroplane*, Vol. 54, No. 1932, June 18, 1948, pp. 728, 729, illus., diagrs.

During compression tests of 24 panels in which stringers were Redux-bonded to the Alclad skins, failure occurred in the Redux bond before it did in the panel in only three cases. The strength of the panels was greater than that of riveted panels tested under identical conditions.

NONMETALLIC MATERIALS

The Weathering of Moulded Plywood Components. L. A. Beaulieu. (*Canada, National Research Laboratories, Division of Mechanical Engineering, Structures Section, Report No. MM-148*, February 19, 1947.) *Aircraft Engineering*, Vol. 20, No. 232, June, 1948, pp. 171–175, 186, illus.

Exposure tests lasting as long as 5 years showed phenol-formaldehyde, melamine-formaldehyde, and polyvinyl butyral to be satisfactory for laminating veneer to be used under outdoor conditions, provided protective coatings are used and maintained and the end grain is protected to hinder moisture penetration and the consequent swelling, delamination, and rotting of the wood.

Laminated "Plexiglas" in Aircraft. II. W. F. Bartoe and E. N. Robertson. *Aero Digest*, Vol. 57, No. 1, July, 1948, pp. 68, 70, 72, 74, 76, 108, 109, figs.

A discussion of the heat transfer characteristics of laminated Plexiglas, methods of controlling the temperature of the interlayer, and the properties of Plexiglas I-A, II-A, and U.V.A. A set of tentative specifications for methacrylate-base sheet plastic laminated with polyvinyl butyral film is proposed. The techniques and practice that must be followed in fabrication, forming, joining, mounting, and attaching of Plexiglas structures illustrate its limitations as a structural material. Bullet impact tests show the laminate to be slightly superior to solid Plexiglas in shatter resistance when the interlayer is maintained at temperatures between 0° and 40°C. No structural benefit can be derived by replacing an equal thickness of solid with the laminate. Unless the proper conditions of fabrication, mounting, and application can be attained, as specified, it is doubtful if the laminate will give as good all-around service as solid Plexiglas of the same thickness.

Recommendations for Basic Stresses. Supplement No. 2 to U.S. Department of Agriculture Miscellaneous Publication 185, "Guide to the Grading of Structural Timbers and the Determination of Working Stresses." *U.S., Forest Products Laboratory, Madison, Wis., Report No. R1715*, June, 1948. 13 pp., fig.

Laminated Fiber-Glass for Aircraft. John H. Beach. *Aero Digest*, Vol. 56, No. 6, June, 1948, pp. 37, 110, 112, 113, illus., diagr.

Conolon, a high-strength material made from fiber-glass impregnated with a modified phenolic resin and modified neoprene and used in the interior of the Convair-Liner, is the first commercial application of laminated fiber-glass for load-bearing aircraft parts. Greater rigidity is obtained than with metal at the same all-over cost and its high thermal-insulation characteristic eliminates insulation on ducting.

New Plastic. John S. Trevor. *Aeronautics*, Vol. 19, No. 1, June, 1948, p. 50. The physical and chemical properties of polytetrafluorethylene, which can be used for packings and gaskets in jet engines and for wire coatings where dielectric strength must be maintained at high temperatures.

A New Adhesive for Industry; 'Araldite' Bonds Metals, Glass, Porcelain and Other Materials. *Aero Research Technical Notes, Bulletin No. 66*, June, 1948. 6 pp., illus., figs.

Metal Bonding (Araldite). *Aircraft Production*, Vol. 10, No. 118, August, 1948, p. 277.

Meteorology (30)

An Objective Method of Forecasting Visibility. James E. Miller and Homer T. Mantis. *American Meteorological Society, Bulletin*, Vol. 29, No. 5, May, 1948, pp. 237–250, figs.

An objective method of forecasting visibility at La Guardia Field, N.Y., in the winter season, is developed from data for the winter of 1943–1944 and tested in the winter of 1944–1945 The method is based on 24-hour air trajectories, which are forecasted by a carefully prescribed routine procedure. The visibility at the origin of a trajectory, the location of the origin, and the final wind velocity implied by the last segment of the trajectory are combined, by means of forecast charts and a formula, to produce a 24-hour forecast of the visibility. Tests of the method show that its accuracy is not much different from the accuracy of visibility forecasts for La Guardia by other methods, but as an objective procedure, it has certain advantages over the normal subjective forecasting methods.

The Albedo of the Ground and Atmosphere. Sigmund Fritz. *American Meteorological Society, Bulletin*, Vol. 29, No. 6, June, 1948, pp. 303–312, illus., figs., tables. 10 references.

A Statistical Analysis of Gust-Velocity Measurements as Affected by Pilots and Airplanes. Harry Press. *U.S., N.A.C.A., Technical Note No. 1645*, June, 1948. 12 pp., figs. 4 references.

A statistical analysis of some of the gust data obtained during the U.S. Weather Bureau Thunderstorm Project at Orlando, Fla., in 1946 indicates that airplane and pilot effects may introduce average errors of about 10 per cent for the effective gust velocities obtained.

Gust Hunting; Work of the B.E.A. Gust Research Unit at Cranfield. *Flight*, Vol. 54, No. 2064, July 15, 1948, pp. 59, 60, 76, illus.

Thunderstorm Probabilities in the United States. A. L. Shands. *American Meteorological Society, Bulletin*, Vol. 29, No. 5, May, 1948, pp. 270–274, figs. 5 references.

A Collection and Evaluation of Weather Forecasting Rules. (*NavAer 50-1R-204.*) *U.S., Naval Postgraduate School, Annapolis, Department of Aerological Engineering*, May, 1947. 98 pp., figs. 10 references.

Observations and Photographs of a Cold Front Made from an Airplane. John H. Conover. *American Meteorological Society, Bulletin*, Vol. 29, No. 6, June, 1948, pp. 313–318, illus., figs.

Aerology Operational Analysis: Selected Illustrations of Radar Storm Detection. II. (*NavAer 50-45T-7A.*) *U.S., Navy, Chief of Naval Operations, Aerology Flight Section*, March, 1948. 16 pp., figs.

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A discussion of the power delivered by light-plane power plants, the range of r.p.m., the determination of proper throttle setting for cruising power, and the influence of propeller size and efficiency on engine speed and power delivery.

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B-36 Mobile Training. *Plane Facts*, Vol. 5, No. 7, July, 1948, pp. 20–23, illus.

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Report on the Aerial Photography of the Ronne Antarctic Research Expedition. William Robertson Latady. *Photogrammetric Engineering*, Vol. 14, No. 2, June, 1948, pp. 205–222, illus., figs. Includes comments on the efficiency of the aircraft and equipment used.

Two Methods of Determining Flying Height. G. T. McNeil. *Photogrammetric Engineering*, Vol. 14, No. 2, June, 1948, pp. 311–315, figs.

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Report of Commission VI—Training (Education), Terminology and Bibliography to the Sixth International Photogrammetry Congress and Exhibition to be Held at The Hague, Netherlands, 1–10 September, 1948. *Photogrammetric Engineering*, Vol. 14. No. 2, June, 1948, pp. 281–287.

Aerial Survey Puts the Commonwealth in the Picture. R. E. Polendine. *Aeronautics*, Vol. 19, No. 1, June, 1948, pp. 48–50.

A summation of the principal aerial mapping projects of Air Survey Co., Ltd., Aerographic Surveys, Ltd., and Aerographic Surveys in the British Commonwealth. Includes a discussion of plant and equipment, aerial photographic technique, plotting from the photographs, and the principles and operation of the Wild Universal Plotting Machine and the Williams-Ross Multiplex apparatus.

Power Plants

Turbo-Jet, Prop-Jet or Piston Engine? *Hawker Review*, Vol. 1, No. 2, May, 1948, pp. 7–15, figs. 7 references.

A series of curves has been developed based on assumptions typical of the transport aircraft likely to be in use during the next 5 or 10 years in order to compare the piston, propeller-turbine, and turbojet engines in speed, altitude, and pay load under transport operating conditions. The propeller-turbine power plant gives greater flexibility of operation than either the piston or the turbojet and affords best results at cruising altitudes above 25,000 ft. At 35,000 ft. it can cruise at 420 m.p.h. with a 10 per cent pay load for 3,500 miles, whereas for the same range and pay load the piston-engined version could only cruise at 340 m.p.h. Below 20,000 ft. the piston engine is most suitable. For speeds above 425 m.p.h. the turbojet is the best type of engine, but it requires an altitude of 35,000 to 40,000 ft. The interrelation of pay load, cruising speed, altitude, and type of engine is plotted for long-, medium-, and short-range transports. If the cruising speed and altitude are selected, the percentage pay load carried, the limitations of the minimum flight speed, and the conditions of no pay load may be found.

JET & TURBINE (5)

Experimental Study of Cooling by Injection of a Fluid Through a Porous Material. Pol Duwez and H. L. Wheeler, Jr. *Journal of the Aeronautical Sciences*, Vol. 15, No. 9, September, 1948, pp. 509–521, figs., tables.

A study of sweat-cooling heat transfer to define the variables involved in this method of engine cooling and to establish experimental techniques to be used in the study of its application to jet engine cooling. Porous cylindrical ducts 1 in. in diameter and $1^1/_2$ in. long of copper, nickel, and stainless steel were retained in a specimen holder and affixed to the outlet of an oxy-hydrogen burner that provided a gas stream of 300 ft. per sec. velocity at 4,200°F. and to the exhaust of a gasoline-air burner that produced a gas temperature of about 2,000° F. but at velocities approaching Mach 1. The coolant, water, hydrogen, or nitrogen under pressure, passed through the walls of the specimen from a small annular space between it and the holder. The surface temperature of the porous duct was a decreasing function of the weight rate of coolant flow when both the temperature and the velocity of the main gas stream remained constant. Beyond a certain value, the surface temperature decreased slowly when the rate of coolant flow increased. Both the temperature and the velocity of the main gas stream affected the relation between the surface temperature and the rate of coolant flow. Since the conditions assumed in most theoretical studies are not those of the experiment, only a fair agreement was obtained between the theoretical and the experimental investigations. The experimental results did indicate, however, that the nature of the porous material had a marked effect on the average heat transfer to the wall of the sweat-cooled specimen.

Aerothermodynamic Design of Turbines for Aircraft Power Plants. John E. Talbert and J. C. Smith. *Journal of the Aeronautical Sciences*, Vol. 15, No. 9, September, 1948, pp. 556–564, diagrs., figs.

A summary of current knowledge of the performance of the expansion or turbine component of aircraft gas-turbine engines which evaluates the progress that has been made in design techniques and enumerates the problems that still remain in the development of high-efficiency, lightweight turbines that can accommodate to a wide range of operating conditions. When the number of stages and the percentage of work to be done by each stage have been decided, the blade angles, root and tip, for both stator and rotor, and the profile shapes most efficient for these angles, under the given operating conditions and restrictions of material strengths are developed. An appendix contains detailed calculations for vector diagram velocities and nozzle areas for a hypothetical 4,000-lb. thrust turbojet engine.

Standardization of Idle Stop Adjustment for Turbo-Jet and Turbo-Prop Engines. I. F. Littman. *U.S., Air Force, Air Materiel Command, Engineering Division, Power Plant Laboratory, Memorandum Report No. MCREXP-540-38*, March 25, 1948. 17 pp.

A summary and a tabulation from a survey of nine manufacturers of aircraft powered by turboengines as to the pertinent design features for idle-stop adjustments. The industry prefers an idle stop for turboprop and turbojet engines which is located on the throttle quadrant in the cockpit, is adjustable, and requires a conscious positive action by the operator to place the throttle lever in the range of travel between the minimum idle position and the fuel cutoff position.

Afterburners for Jet Engines. F. A. Cleveland. Letter to the Editor. Günther Helmecke. *Journal of the Aeronautical Sciences*, Vol. 15, No. 9, September, 1948, p. 521.

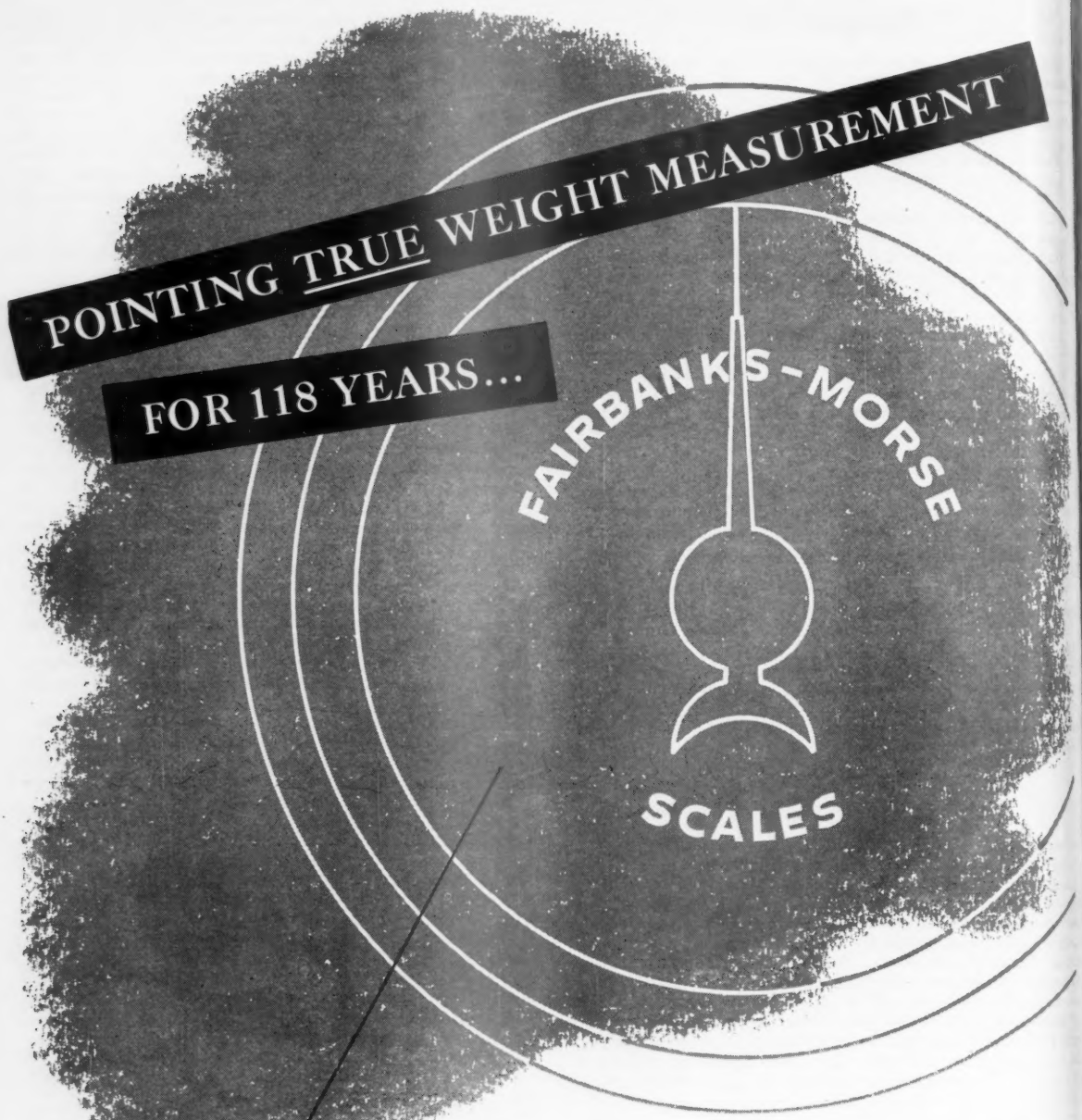
A Theoretical Calculation of the Reduction in Drag Obtainable by Ejector Action of the Exhaust Gases When Mixed with the Cooling Air-Flow of a Typical Air-Cooled Engine. A. B. P. Beeton. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2302*, April, 1945. 8 pp., figs. British Information Services, New York. $0.70.

The formulas for the thrust theoretically obtainable in a system where the ejector exhaust is mixed with the engine cooling air are of such complexity that they cannot be applied generally. They do show, however, that there is an optimum size of the mixing duct in relation to the exhaust-pipe diameter and that the effect of mixing the exhaust gas and the cooling air streams is beneficial only when the available total pressure head behind the engine is small.

Electronic Analog Studies for Turboprop Control Systems. G. A. Philbrick, W. T. Stark, and W. C. Schaffer. *SAE Quarterly Transactions*, Vol. 2, No. 2, April, 1948, pp. 234–241, diagrs., figs.

The principles, design, and operation of the Wright Aeronautical Corporation electronic analog. When the instrument is set from calculated or empirical data, its oscilloscopic time-plot display shows the behavior of the important variables of a turboprop control system during and after applied transient disturbances. The computing device simulates the physical relationships that exist among the five prime variables: speed, torque, temperature, fuel flow, and propeller blade angle. The optimum values may be determined for as many as 25 design characteristics in 1 day.

Performance of NACA Eight-Stage Axial-Flow Compressor Designed on the Basis of Airfoil Theory. John T. Sinnette, Jr., Oscar W. Schey, and J. Austin King. *U.S., N.A.C.A., Report No. 758*, 1943. 19 pp., diagrs., figs. 36 references. U.S. Govt. Printing Office, Washington. $0.20.



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Research Review on Raising Turbine Inlet Temperature. Robert McLarren. *Aviation Week*, Vol. 49, No. 2, July 12, 1948, pp. 27, 28. 6 references.

Design of the turbine disc so that the maximum stresses caused by temperature distribution are away from the critical area and the use of cooled blades will permit an increase in turbine inlet temperatures and an increase in power. The most promising method of cooling turbine blades is to use a porous material, such as a sintered metal, through which the coolant is forced from the hollow interior to the surface of the blade.

Development of Bigger Ramjets Awaits Combustion Data. W. H. Goss and Emory Cook. *SAE Journal*, Vol. 56, No. 7, July, 1948, pp. 53–55, diagr. (Extended summary of a paper: The Ramjet as a Supersonic Propulsion Plant.)

A Three-Dimensional Theory of Turbine Flow and Its Application to the Design of Wheel Vanes for Francis and Propeller Turbines. Ludwig Arthur Dreyfus. (Recd. July 7, 1944.) (*Ingeniörsvetenskapsakademi, Handlingar Nr. 188*, 1946.) *Acta Polytechnica* (Stockholm), No. 1 (*Mechanical Engineering Series*, Vol. 1, No. 1), 1947. 113 pp., diagrs., figs. Sw. Kr. 12.

Application of Statistical Methods to Study of Gas-Turbine Blade Failures. Charles A. Hoffman and G. Mervin Ault. *U.S., N.A.C.A., Technical Note No. 1603*, June, 1948. 27 pp., illus., diagr., figs. 3 references.

A study of the application of statistical methods to the evaluation of performance characteristics of turbine rotor blades. An investigation of the life of the individual blades in turbine rotors shows that the time for first failure may not, in general, be taken as an accurate indication of the performance of the average blade. During research and development of blade materials a need exists for the representative performance-life values that statistical methods of analysis yield in order to avoid the errors in comparative evaluation and correlation of the properties of materials which may result from considering only initial failures or from too few tests. Improved inspection techniques and processing may narrow the wide distributions and increase the life expectancies of turbine blades.

Determination of Stresses in Gas-Turbine Disks Subjected to Plastic Flow and Creep. M. B. Millenson and S. S. Manson. *U.S., N.A.C.A., Technical Note No. 1636*, June, 1948. 45 pp., figs. 7 references.

The finite-difference method of calculating elastic stresses in gas-turbine discs is extended to include consideration of plastic flow and creep. Examples illustrate the calculation of stresses during one turbine-operating cycle, stresses in a disc with central hole, and other stresses. The results of the numerical examples indicate qualitatively that plastic flow markedly alters the elastic-stress distribution and that, if the amount of creep is small, the effect on stress distribution is also small.

Effect of Strength and Ductility on Burst Characteristics of Rotating Disks. Arthur G. Holms and Joseph E. Jenkins. *U.S., N.A.C.A., Technical Note No. 1667*, July, 1948. 52 pp., illus., figs. 5 references.

An investigation was conducted to determine the influence of strength and ductility on room-temperature burst characteristics of solid discs, discs with large-diameter central holes, and discs with small-diameter central holes. Ductility varied from 3.4 to 52.8 per cent conventional elongation. For all designs, disc strength increased with increasing tensile strength, and the ratio of disc strength to tensile strength was found to be relatively independent of ductility.

The Manufacture of Turbine Blades for the Whittle Engine. T. A. Kestell. *Institution of Mechanical Engineers, Proceedings*, Vol. 158, No. 1, 1948, pp. 66–82, Discussion, pp. 83–91, Communications, pp. 91–94, diagrs., figs., tables., 6 pp. of illus.

A detailed presentation of the principles, the development of the design, and the construction of the Kestell blade-profiling machine. By grinding, turning, or milling, the machine produces the exact turbine-blade profile specified by the designer by means of a constant-orbit mechanism that will produce a form approximating the required profile whose orbit is modified by a correction cam. Different cams are required for internal and external shaping. Methods of their design, manufacture, and correction so that they translate the blade profile into a three-dimensional cam, discussion of other copy-milling methods, and an evaluation of this method are included.

The Tecalemit Micro Pump. D. G. Thorpe. *The Technical Instructor*, Vol. 3, No. 6, June, 1948, pp. 11, 12, diagr.

Design and construction of a pump that has no valves and a zero clearance volume in its displacement cavity. It can meter accurately when there is a pressure differential between the pump inlet and outlet. They have been designed to operate at speeds up to 5,000 r.p.m. discharging up to 75 cc. per min. at an inlet pressure of 500 lbs. per sq.in. Others have been designed with a pressure of only 10 lbs. per sq.in. The pump is intended for the accurate lubrication of supercharger rotor and gas-turbine main-shaft bearings.

Mains Trolley Starting for Turbines. *The Aeroplane*, Vol. 75, No. 1936, July 16, 1948, p. 88, illus.

Mamba—Featherweight Turbine (Armstrong Siddeley). *Aircraft*, Vol. 26, No. 9, June, 1948, pp. 20, 21, 44, 45, illus., diagrs.

Snow on the Jet Pipe. *Hawker Review*, Vol. 1, No. 2, May, 1948, pp. 21, 22, illus., figs. A description of the "150-hour test" which the Armstrong Siddeley Mamba completed successfully under severe winter conditions.

Inside the (Armstrong Siddeley) Mamba. D. M. Desoutter. *Aeronautics*, Vol. 19, No. 3, August, 1948, pp. 43–48, colored cutaway drawings.

Canada's First Jet Engine Avro Chinook Makes Debut. *Aircraft and Airport*, Vol. 10, No. 4, April, 1948, pp. 31, 32, illus.

Power for the Giants; Preliminary Description of the Bristol Proteus Turboprop Unit; Brabazon and S.R.45 Coupled Installations in Detail. *Flight*, Vol. 54, No. 0267, August 5, 1948, pp. 153–157, illus., cutaway drawing.

Five Hundred Hours; Remarkable Endurance Test of Bristol Theseus Turboprop. *Flight*, Vol. 54, No. 2065, July 22, 1948, p. 92, illus.

Civil Approval for the Ghost; The D.H. Comet Advances Through Another Development Stage. *Flight*, Vol. 54, No. 2065, July 22, 1948, p. 93, illus.

Engine Installation Problems in the (Republic) XP-84 Airplane. R. R. Higginbotham. *SAE Quarterly Transactions*, Vol. 2, No. 2, April, 1948, pp. 268–287, illus., diagrs., figs.

A discussion in detail of the problems that arose in the installation of the General Electric TG-180 turbojet engine in the Republic XP-84 Thunderjet fighter. These included provision for quick engine replacement, reduction of losses that arose in the long split inlet duct, the development of a tight joint between the tailpipe and the engine, thermal protection of the fuselage, provision for adjusting the tailpipe area, and the design of the normal and emergency fuel systems and their controls. During flight tests the engine displayed disappointing rotational acceleration, rapid deterioration of compressor performance with age, excessive starter current, and unsatisfactory regulator performance. Suggestions are offered as to the probable causes of these deficiencies and possible methods of correcting them.

Foremost American Turbojet; Some Details of the Slim Axial-Flow (G.-E.-Allison) J-35. *Flight*, Vol. 54, No. 2067, August 5, 1948, p. 163, cutaway drawing.

The "Nene" Passes with Honors (Pratt & Whitney J42-P-8 Gas Turbine). *Aero Digest*, Vol. 57, No. 1, July, 1948, pp. 26, 27, 114, illus.

New Laboratory for Jet-Engine Components (General Electric Company, Lynn, Mass.). *American Rocket Society, Journal*, No. 74, June, 1948, pp. 74, 75.

Jet Engine Test Laboratory (General Electric). *Aero Digest*, Vol. 57, No. 1, July, 1948, pp. 46, 47, illus.

Lifting the Secrecy Lid on the Packard Gas Turbine Research Plant. *Automotive Industries*, Vol. 99, No. 3, August 1, 1948, pp. 42, 43, illus.

Air to Burn. George E. Slye. *The Bee-Hive*, Vol. 23, No. 3, Summer, 1948, pp. 3–8, illus. Description of the equipment, instrumentation, and power supplies of the Pratt & Whitney Aircraft Laboratory for testing compressors for aircraft gas-turbine engines.

Canada's Turbojet Test Facilities (A. V. Roe Canada Ltd.). *Automotive Industries*, Vol. 90, No. 2, July 15, 1948, pp. 28, 29, 64 illus.

Jet Engine Combustion Research. *Aero Digest*, Vol. 57, No. 1, July, 1948, pp. 57, 120, 121, illus.

Brief summary of the topics under investigation in the combustion research program of the Westinghouse Research Laboratories, and summary of a paper by Reinout P. Kroon of the Westinghouse Aviation Gas Turbine Division on the progress made in the development of jet engines.

RECIPROCATING (6)

Knocking Combustion Observed in a Spark-Ignition Engine with Simultaneous Direct and Schlieren High-Speed Motion Pictures and Pressure Records. Gordon E. Osterstrom. *U.S., N.A.C.A., Technical Note No. 1614*, June, 1948. 59 pp., illus., diagrs. 13 references.

Simultaneous direct and schlieren photographs at 40,000 frames per sec. and correlated pressure records were taken of knocking combustion in a special spark-ignition engine to ascertain the intensity of certain end-zone reactions previously seen by schlieren photography alone. The first stages of preknock autoignition process as seen in schlieren photographs did not emit enough light to be photographed directly; the last stages emitted enough light in one instance. A violent propagated homogeneous autoignition, observed previously, was observed again. Extensive autoignition without occurrence of gas vibrations was seen in one explosion. The pressure records show autoignition of varying violence before passage of a detonation wave.

A High-Output Reciprocating Engine Design. A. Castellini. *Aircraft Engineering*, Vol. 20, No. 232, June, 1948, pp. 179–181, diagrs.

Description of the design and performance of the Lindum aircraft engine, a geared, medium-supercharged, 16-cylinder, two-stroke, radial unit rated at 4,000-hp. at 2,500 r.p.m. It has an estimated power-weight ratio of 0.3 lb. per b.hp. Inlet valves are seated in the piston head and are actuated by the connecting rod, which permits the individual timing of each cylinder. The exhaust valves are operated by push rods and are located in the cylinder head. This design combines the higher mechanical efficiency of the two-stroke system with the higher thermal and volumetric efficiency of the four-stroke system.

Effect of Preignition on Cylinder Temperatures, Pressures, Power Output, and Piston Failures. Lester C. Corrington and William F. Fisher. *U.S., N.A.C.A., Technical Note No. 1637*, June, 1948. 43 pp., illus., diagr., figs. 1 reference.

Preignition led to backfiring into induction system, caused large increases in cylinder temperatures and pressures, large decreases in power output, and piston failures due to overexpansion of piston and seizure in cylinder. Failures could be minimized by increasing clearance between piston and cylinder.

The Diagnosis of Engine Valve Failures. Vincent Ayres. *Eaton Engineering Forum*, Vol. 9, No. 2, July, 1948, pp. 2–8, illus., table.

A tabulation of the possible causes of each type of valve failure and the corrective maintenance that is within the scope of the engine operator. Illustrations of typical failures provide a guide to the identification of the various failures.

Fuel Injection Versus Carburetion for Personal Airplane Engines. *SAE Quarterly Transactions*, Vol. 2, No. 2, April, 1948, pp. 210–219, illus., diagr., figs. 9 references. (Cf. AER 6/47:36.)

Principles of Carburation and Supercharging. B. H. Ware. *The Technical Instructor*, Vol. 3, No. 7, July, 1948, pp. 3–10, diagrs.

Fluid Drive for (Stratos) Supercharger. *Aircraft and Airport*, Vol. 10, No. 4, April, 1948, p. 39, diagr.

Master Control Fuel Injection System for Aircraft Engines. III. H. M. Hobson Ltd. *The Technical Instructor*, Vol. 3, No. 6, June, 1948, pp. 1–10, diagrs., figs.

Detailed description of the metering system of the Hobson fuel-injection carburetor. The fuel-metering needle valve is actuated by a composite aneroid capsule assembly and by a Bourdon tube through a system of levers. Changes in atmospheric pressure under both cruising conditions and conditions requiring increased boost are compensated for automatically.

The Induction of Water to the Inlet Air as a Means of Internal Cooling in Aircraft-Engine Cylinders. Addison M. Rothrock, Alois Krsek, Jr., and Anthony W. Jones. *U.S., N.A.C.A., Report No. 756*, 1943. 13 pp., figs. 6 references. U.S. Govt. Printing Office, Washington. $0.15.

Increased Ignition Power of Electric Sparks by Locally Changing the Composition of the Gas Mixture. H. Mache. (*Österreichisches Ingenieur Archiv*, Vol. 1, No. 4-5, 1947, pp. 273–277.) *The Engineers' Digest*, Vol. 5, No. 5, July, 1948, p. 265, fig.

Internal Combustion Engine Valves. *Lubrication*, Vol. 34, No. 7, July, 1948, pp. 73–84, illus., figs. 2 references.

The design, function, materials, and operating conditions of poppet valves of internal combustion engines. Most valve failures are due to either breaking or burning of the valve. These can be reduced by correct selection of the type of valve and the materials of the valve and the block seat and by proper design. In order to achieve a minimum of failure, maintenance practice must include periodic checks to determine the condition of the valve, valve tappet clearances, and compression pressures to determine whether refacing, grinding, or replacement of valve seats, valve guides, and springs is required.

Engine Servicing Trolley; Easy Inhibition of Engines While in Store. *Flight*, Vol. 54, No. 2067, August 5, 1948, p. 157, illus.

Factors Affecting Functioning of Spark Plugs. W. A. Bychinsky. *SAE Quarterly Transactions*, Vol. 2, No. 2, April, 1948, pp. 255–267, illus., diagrs., figs.

A history of the development of spark plugs and spark-plug insulating materials and a description of their structure; their mechanical, electrical, and thermal operating characteristics; methods of rating; causes of failure; and their performance as an index of the functioning of the engine.

Allison V-1710 Compounded Engine. Dimitrius Gerdan and J. M. Wetzler. *SAE Quarterly Transactions*, Vol. 2, No. 2, April, 1948, pp. 329–338, illus., figs.

The results of tests on the Allison V-1710 exhaust-turbine compounded reciprocating aircraft engine showed that compounding markedly increased power output and reduced specific fuel consumption. The two-stage supercharged engine with a geared exhaust-driven turbine that was built and tested was designated as the Allison Model V-1710-E27. Compounding boosted its power from 1,200 to 1,500 b.hp. at 30,000 ft. and 3,200 r.p.m. Despite these promising results, the project was dropped because it was felt that the engineering man power needed to develop a turbine capable of withstanding maximum exhaust-gas temperatures would be better employed on turboprop development.

Engine Compounding for Power and Efficiency. E. F. Pierce and H. W. Welsh. *SAE Quarterly Transactions*, Vol. 2, No. 2, April, 1948, pp. 316–328, 344, diagr., figs. 6 references.

An analysis of power recovery from the exhaust gases of aircraft reciprocating engines for systems in which the exhaust from each cylinder is used separately and for cases where it is first collected in an exhaust manifold and then discharged in an essentially steady-flow stream. Systems using the exhaust from each cylinder directly can be designed with greater simplicity, do not create as great a problem of high exhaust-gas temperatures, and do not produce so high exhaust-gas pressures as those of the pressure systems which adversely affect the detonation characteristics of the engine. The jet stack system appears to be suited to short-range, high-speed flight. The augmenter system is best suited to short-range, low-speed flight. The pressure-turbine system is indicated for long-range, high-altitude flight.

Chinese Aircraft Engine Factory. H. C. Tsien. *Aero Digest*, Vol. 56, No. 6, June, 1948, pp. 58–60, 108–110, illus. Establishment, personnel, and production problems of the underground aircraft and automotive manufacturing and maintenance plant at Kweichow, China.

Piston Engine Boosted to 4000 Hp.; Both Wright and Pratt & Whitney Producing New-Type Powerplants Promising Startling Low Fuel Consumption. *Aviation Week*, Vol. 49, No. 6, August 9, 1948, pp. 12, 13.

Bristol's Clover Engine Cowling Developments. *The Aeroplane*, Vol. 74, No. 1933, June 25, 1948, p. 752, illus.

A Novel Power Plant (Jameson F.F.-1 Horizontally Opposed 4-Cylinder Air-Cooled Engine). *The Aeroplane*, Vol. 75, No. 1938, July 30, 1948, pp. 135, 136, illus., diagrs.

Stratocruiser Power Package Change. *Boeing Service Guide*, No. 10, July, 1948, pp. 2–9, illus., diagrs., tables.

ROCKET (4)

The Man-Carrying Rocket. R. A. Smith. *British Interplanetary Society, Journal*, Vol. 7, No. 3, May, 1948, pp. 100–111, diagrs.

Outline of a project submitted to the Ministry of Supply in 1946 to determine the physiological effects of variation in gravitational datum and other conditions encountered in rocket flight; to check by direct observation high-altitude data; and to obtain radio-transmission, photographic, and spectrographic data at an altitude of 225 miles. A modification of the A.4 series

of German turborockets is to be controlled during ascent by a pilot in a jettisonable pressurized cabin. A constant-drag hull parachute provides for safe descent.

What's Ahead for Rockets? *Aviation Week*, Vol. 49, No. 1, July 5, 1948, p. 23.

A survey of the opinion of the rocket industry by the Daniel and Florence Guggenheim Foundation under the direction of G. Edward Pendray predicted that in the next 10 years rockets would find commercial application. The field at present needs more research; a coordination of existing research and development programs; long-range financial backing; and a greater number of adequately trained scientists, particularly in the fields of dynamics, chemistry, and mechanics. Although the Government research program is comprehensive, private research would be desirable. Current progress could be hastened by the establishment of educational programs to train scientific and engineering personnel.

Robert H. Goddard, Father of Modern Rocketry. J. H. Doolittle. *American Rocket Society, Journal*, No. 74, June, 1948, pp. 53–61, illus.

Production (36)

Investigation into Spacing of Spotwelds. H. Dudley Wimer, Jr. *Aero Digest*, Vol. 57, No. 1, July, 1948, pp. 66, 67, 117, 118, 120, figs. 1 reference.

The derivation and method of using the "Special Welding Spacing Chart." From the thickness of the controlling sheet and the thickness of the remainder of the pile, the minimum spacing is indicated for spot welding done with standard procedure or with a modified procedure using two current settings: one for the first weld, and an increased setting for the subsequent welds. The accuracy of the chart was verified experimentally. It applies only to 18-8 stainless-steel spot welding in which the spacing is the single deviation from standard practice.

Flash Butt Welding. III—Post-Welding Tests; Results of Main Programme; The Work Discussed. S. G. E. Nash, H. Brooks, and M. A. Garnett. *Aircraft Production*, Vol. 10, No. 117, July, 1948, pp. 243–247, figs. 2 references.

The Welding of High Melting Point Metals. XIII—The Welding of Non-Ferrous Metals. E. G. West. *Sheet Metal Industries*, Vol. 25, No. 256, August, 1948, pp. 1621–1626, figs. 17 references. Tungsten, molybdenum, tantalum, titanium, cobalt, chromium, manganese, and zirconium.

Joining Light-Alloy Sheet; Simple Pierce Riveting Process for Unstressed Components. *Aircraft Production*, Vol. 10, No. 118, August, 1948, p. 265, figs.

Vampire Production. III—Wing Sub-Assemblies and Final Assembly; Machining Elliptical Joint-Rings; Tail Booms. S. C. Poulsen. *Aircraft Production*, Vol. 10, No. 117, July, 1948, pp. 221–229, illus., cutaway drawings.

Saunders-Roe SR 45; Conception and Design of a 140-Ton Flying Boat: Tooling Simplified by "Shipbuilding" Technique: Extrusion Manipulation and Frame Manufacture. Wilfred E. Goff. *Aircraft Production*, Vol. 10, No. 118, August, 1948, pp. 266–272, illus., diagrs., cutaway drawings.

Expanding Spar-Jig; Hole Centres Controlled by Light-Alloy Compensating Bar in New Avro Tool. *Aircraft Production*, Vol. 10, No. 118, August, 1948, p. 256, figs.

Unconventional Tooling; Production of de Havilland Dove Parts on the Rubber-Die Press. J. S. Needham. *Aircraft Production*, Vol. 10, No. 118, August, 1948, pp. 253–255, figs.

Centreless Plunge-Grinding; Application of Automatic Loading and Operation Control. *Aircraft Production*, Vol. 10, No. 117, July, 1948, p. 231, figs.

Jig Grinding; Some Notes on a Process for Accurately Finishing Bores, Slots and Other Internal Contours in Hardened Materials. W. Boneham. *Aircraft Production*, Vol. 10, No. 118, August, 1948, pp. 282–284, illus., figs.

Fork-Lift Trucks; A Modern Development in Works Transport; The Pallet System of Lifting and Stacking. Raymond T. Hartmann. *Aircraft Production*, Vol. 10, No. 118, August, 1948, pp. 275–277.

Optical Alignment; "Self-Checking" Principle in New Hilger and Watts Instrument. *Aircraft Production*, Vol. 10, No. 117, July, 1948, pp. 241, 242, illus., diagr.

Form Dressing; Operation of the Improved Diaform Attachment; Translation of Template Contours by Pantograph System. *Aircraft Production*, Vol. 10, No. 117, July, 1948, pp. 235–237, diagrs.

Tube-Bending; High-Production, Hydraulically Controlled Machine Developed and Operated by Vickers-Armstrong, Ltd. *Aircraft Production*, Vol. 10, No. 117, July, 1948, pp. 232–234, illus., diagrs.

Gas Carburizing; Use of a Catalyst to Reduce Scale Formation. *Aircraft Production*, Vol. 10, No. 117, July, 1948, pp. 230, 231.

Work Measurement. II—Some Practical Considerations; Economy of Motion; Methods of Time-Study. J. J. Gracie. *Aircraft Production*, Vol. 10, No. 117, July, 1948, pp. 239, 240, figs.

Shotpeening. Fred K. Landecker. *SAE Quarterly Transactions*, Vol. 2, No. 2, April, 1948, pp. 191–194, 200, diagr., figs. 1 reference.

Spun Glass Aids in Metal Forming (at The Glenn L. Martin Co.). *Aviation Week*, Vol. 49, No. 4, July 26, 1948, p. 27, illus.

Machine Tools at Olympia; Equipment of Interest to the Aircraft and Light Engineering Industries: A Preliminary Review. *Aircraft Production*, Vol. 10, No. 118, August, 1948, pp. 257–263, illus.

Quarterly Backlog Report Studied. *Aviation Week*, Vol. 48, No. 25, June 21, 1948, p. 17, table.

Canadair, A Vital Link in Canada's Aircraft Industry. Albert Turner. *Aircraft and Airport*, Vol. 10, No. 4, April, 1948, pp. 14–16, 18, 20, 26, 28, 50, illus.

In and Around de Havilland's of Canada. *The Aeroplane*, Vol. 74, No. 1932, June 18, 1948, pp. 730, 731, illus.

The Australian de Havilland Company is Twenty-One Years Old. *De Havilland Gazette*, No. 45, June, 1948, pp. 8–11, illus.

Coming of Age; 1927–1948; Growth of de Havilland's Australian Company. *Flight*, Vol. 53, No. 2061, June 24, 1948, pp. 700, 701, illus.

Propellers (11)

Wind-Tunnel Tests and Analysis of Two 10-Foot-Diameter Six-Blade Dual-Rotating Tractor Propellers Differing in Pitch Distribution. Jean Gilman, Jr. *U.S., N.A.C.A., Technical Note No. 1634*, June, 1948. 42 pp., figs. 8 references.

Data obtained in tests to determine the efficiency at low tip speeds were in satisfactory agreement with efficiency, blade loading, thrust, and torque characteristics calculated analytically from two-dimensional airfoil-section data. A dual-rotating propeller of low design pitch maintained an efficiency at advance ratios greater than 2.5, which was high when compared with a similar single-rotating propeller operating in the same range. The induced efficiency of dual-rotating propellers near peak efficiency was relatively independent of blade load distribution.

Icing and De-Icing of a Propeller with Internal Electric Blade Heaters. James P. Lewis and Howard C. Stevens, Jr. *U.S., N.A.C.A., Technical Note No. 1691*, August, 1948. 51 pp., illus., figs. 5 references.

Deicing effectiveness of an internal electric propeller-blade heater was determined at two icing and two operating conditions with heat applied continuously and cyclically. Chordwise extent of icing was greater than that covered by blade heaters. Adequate deicing in heated area with continuous heating was obtained with power available, but maximum power input of 1,250 watts per blade was insufficient for cyclic deicing. Surface temperature-rise rates of 0.2° to 0.7°F. per sec. were obtained, and minimum cooling period for cyclic deicing was approximately $2^1/_2$ times the heating period.

Sound From Dual-Rotating and Multiple Single-Rotating Propellers. Harvey H. Hubbard. *U.S., N.A.C.A., Technical Note No. 1654*, July, 1948. 31 pp., illus., figs. 5 references.

Sound measurements for static conditions are presented for multiple propellers and the results are compared with a theoretical analysis of the problem. The sound from a four-blade dual-rotating propeller was found to fluctuate approximately between that from a two-blade and a four-blade single-rotating propeller when the propellers are absorbing the same power at the same tip speed. The amount of fluctuation was found to depend on the angle of overlap with respect to the observer.

Safety and Operational Gains Seen for Reverse-Pitch Props. M. G. Beard. *SAE Journal*, Vol. 56, No. 7, July, 1948, pp.

Here's PROOF of why MARTIN 2-0-2 Airliners Spell PROFITS for Airlines:

Northwest Airlines, first domestic airline to modernize its twin-engine fleet, has found in nearly a year of service that the Martin 2-0-2 airliner means:

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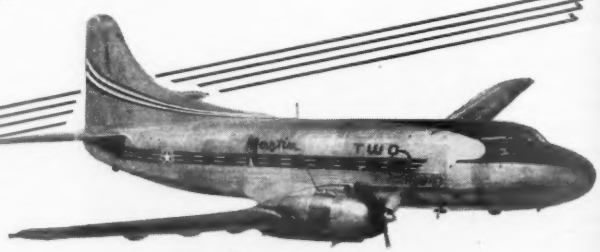

"FLAK BAIT," Devon Francis' new book (Duell, Sloan & Pearce), is the thrilling story of the heroic men who flew and serviced Martin B-26 Marauders in bomber strikes from the Southwest Pacific to the Aleutians; from North Africa to the gates of Berlin. The Glenn L. Martin Company is proud to be mentioned in the combat roll call of these gallant airmen.

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57–61, diagr., fig. (Extended summary of a paper: Practical Aspects of Reverse-Thrust Propellers in Airline Operation.)

Hamilton Standard's Hollow Steel Blade. *Plane Facts*, Vol. 5, No. 6, June, 1948, pp. 10, 11, 32, illus.

Arc-Welded Airscrew-Hubs; Economical Technique in the Production of an American Design (Aeromatic). Clarence C. Mast, Paul F. Hackethal, and Douglas W. Hamilton. *Aircraft Production*, Vol. 10, No. 117, July, 1948, pp. 219, 220, illus.

Arc Welding Shrinks Prop Hub Cost, Weight. John D. Waugh. *SAE Journal*, Vol. 56, No. 7, July, 1948, pp. 33–39, figs. (Extended summary of a paper: Arc Welded Propeller Hubs Reduce Cost-Weight.)

Rotating Wing Aircraft (34)

A Tabular Method of Calculating Helicopter Blade Deflections and Moments. N. O. Myklestad. *Journal of Applied Mechanics*, Vol. 15, No. 2, June, 1948, pp. 97–106, figs. 1 reference.

The shear forces, bending moments, slopes, and deflections can be determined by performing a series of tabular calculations. The load is first put in the form of a constant term and a series of harmonic terms. Each of the latter must be analyzed separately. The effects of the constant load and the eccentricity and the slope at the base of the blade axis are found together in two tabular calculations involving only real quantities. The effect of each harmonic requires three tabular calculations. The phase angles, which vary along the axis of the blade, are taken care of with complex numbers. The method assumes that the blade rotates about a fixed axis with a constant angular velocity subjected to a known load parallel to the axis of rotation. The blade axis, while not necessarily a straight radial line, must have only a small deviation. One of the principal axes of moment of inertia for each cross section is parallel to the axis of rotation and bending takes place through this axis.

Stability of Lifting Rotors. G. von Sissingh. (*ZWB/TB/-11-10*, October, 1944.) *U.S., Air Force, Translation No. ATI 19599*, June, 1948. 5 pp. 3 references.

An investigation of the equations of motion of a rotor with twisted rectangular blades and central horizontal hinges to determine the transient motion arising in transition from one flight condition to another. It is assumed that, in the steady flight condition to which the blades are tending, the rotor has no rotational movement except its own rotation proper and that the velocity of flight and direction of motion are constant. When applied to a numerical example the results show the aerodynamic damping to be so strong that the flapping motion adjusts itself almost instantly to the new flight condition and the stability of flapping is not influenced by the tip-speed ratio.

Stability Experiments with Models. John E. Burkam. *American Helicopter*, Vol. 11, No. 8, July, 1948, pp. 8–10, 19–22, illus. 4 references. Description of tests with powered helicopter models to determine the inherent stability provided by different types of blade attachments and balance bars and hub freedom.

New Coaxial Rotor Design. G. F. Champlin. *American Helicopter*, Vol. 11, No. 7, June, 1948, p. 16, illus.

A single wheel provides full control of coaxial twin helicopter rotors. Rotation of the wheel increases or decreases the blade pitch. Raising or lowering the wheel controls the cyclic pitch, and lateral translation of the wheel shifts the maximum-minimum pitch line to control the direction of flight.

New Blades for Better Helicopters. *Aviation Week*, Vol. 48, No. 24, June 14, 1948, pp. 23, 24, 33, figs.

Lift-drag coefficient curves, pressure distribution, pitching moment coefficient, plot of lift coefficient vs. angle of attack, and profile data for the H-series airfoil developed by the N.A.C.A. for helicopter rotor blades. Extensive laminar boundary layer is retained for high lift-drag ratios, and pitching moment is reduced by a reflex trailing edge.

Development of Rotor Blades. George H. Linnabery. *Aero Digest*, Vol. 57, No. 1, July, 1948, pp. 54, 55, 105, 106, figs.

The materials, design, and methods used by the Bell Aircraft Corporation in the fabrication of helicopter rotor blades. Hickory was initially used for the leading edge, with white pine for the remaining portion in the solid wood blades and a hollow blade with birch plywood skin. Subsequently, a semi-impregnated birch laminate replaced the hickory, and a hollowed section was used for the trailing edge. In the final design the center portion of the blade was solid white pine with a trailing edge of balsa wood. Glass cloth doped to the surface of the blade replaced the nylon that was originally used. In all designs, the leading edge was protected from abrasion by a sheet of 0.019 in. stainless steel. Shaping the blades to templates with a tolerance of 0.015 in. was done by hand. In production, a semiautomatic cutting machine that cuts to a depth determined by preset cams is used for initial roughing.

U.S. Air Force Helicopter Development. G. F. Champlin. *American Helicopter*, Vol. 11, No. 8, July, 1948, pp. 14–16, 22, illus.

B.E.A. Helicopter Experiment. C. Colin Cooper. *American Helicopter*, Vol. 11, No. 8, July, 1948, p. 11, illus.

New California Helicopter Service (General Electric Jet-Propelled-Helicopter Test Facilities). Fanchon Devoe. *American Helicopter*, Vol. 11, No. 9, August, 1948, p. 17, illus.

GE Opens Test Facilities for Jet-Propelled Helicopters. *American Rocket Society, Journal*, No. 74, June, 1948, pp. 69, 70.

Testing Arm for Rotors. M. Berry. *American Helicopter*, Vol. 11, No. 8, July, 1948, pp. 6, 7, illus.

A rotating arm developed by the Rotawings Division of The Glenn L. Martin Company to simulate flight conditions in the testing of models of helicopter rotors and hubs. The stand can accommodate any standard proportional rotor hub with 10-ft diameter blades for testing mechanical stability, control, or vibration characteristics.

First British Helicopter Mail Service. *The Aeroplane*, Vol. 54, No. 1931, June 11, 1948, p. 709, map.

The Versatile Windmills. Malcolm W. Cagle. *U.S. Naval Institute, Proceedings*, Vol. 74, No. 545, July, 1948, pp. 832–835, illus.

The versatility of the helicopter and its comparative independence of weather conditions have made it a valuable adjunct to fleet operations in sea-air rescue, submarine spotting, torpedo chasing, fire control, plane guard, shipshore and intership liaison, and messenger service.

Social Uses of the Helicopter. Lawrence D. Bell. *Air Affairs*, Vol. 2, No. 3, July, 1948, pp. 380–392.

Social Uses of the Helicopter. Lawrence D. Bell. *American Helicopter*, Vol. 11, No. 9, August, 1948, pp. 6–8, 19–21, illus.

First Rooftop Ambulance Service. Frank Coleman. *American Helicopter*, Vol. 11, No. 8, July, 1948, p. 17, illus.

The Facts and Figures on Commercial Operation. I, II. Knute Flint. *American Helicopter*, Vol. 11, Nos. 7, 8, June, July, 1948, pp. 6, 7, 18, 19; 12, 13, 22, 23.

I. During 1 year of operation the four Bell helicopters of the A-F Helicopters, Inc., have flown 16,000 hours. Their operations included pilot training, power-line patrol, forest-fire fighting, observation, crop dusting and spraying, and frost prevention. Rates, operating procedure, and a report of Governmental relations and attitudes are commented upon. **II.** A discussion of the maintenance and financial aspects of helicopter operation. A preventive maintenance schedule has kept the helicopter fleet of A-F Helicopters, Inc., available for operation 85 per cent of the daylight hours. Each helicopter requires about $38,000 for the initial investment and working capital. Includes discussion of insurance rates and a financial statement covering a period of about $10^1/_2$ months operation.

The Helicopter Forum. I, II. Alexander Klemin. *Aero Digest*, Vol. 56, No. 6, June 1948, pp. 62, 65, 120; Vol. 57, No. 1, July, 1948, pp. 53, 82, 121, 122; figs.

I. Summaries of papers and comments: Notes on the Flying Qualities of Helicopters, John B. Reeder and F. B. Gustafson. Contribution of the Problem of Helicopter Stability, Kurt Hohenemser. Gyroscopic Forces on Hinged Rotors, Garry C. Meyers. Lubrication Problems in Helicopter Transmission, Robert A. Wolf and Arthur N. Lapping. Co-Axial Design for Helicopter Mass Production, Rowland J. Watson. Attacking the Maintenance Problem Through Mechanical Design, Glidden S. Doman. Helicopter Problems Past and Present, Serge Gagarin. A paper by Lee L. Douglas on the design and performance of rotor-blade dampers. **II.** A review of papers on operations and economics.

Co-Axial Helicopter Development (Bendix). *The Aeroplane*, Vol. 54, No. 1931, June 11, 1948, pp. 712, 713, illus.

Bristol Type 171. M. Berry. *American Helicopter*, Vol. 11, No. 9, August, 1948, pp. 9, 10, 21, 22, illus.

The (Fairey) Gyrodyne. J. A. J. Bennett. *Flight*, Vol. 54, No. 2064, July 15, 1948, pp. 78, 79. (Summary of a paper.)

The Gyrodyne; Mechanical Features of the Fairey Helicopter. II. *Flight*, Vol. 54, No. 2065, July 22, 1948, pp. 106, 107, illus.

New Coaxial Rotor Helicopter; Built by Small Staff of Engineers (Jensen Helicopter Co. Model 21). *Aviation Week*, Vol. 49, No. 5, August 2, 1948, pp. 25, 26, illus.

Rotachute Kite. Igor B. Benson. *American Helicopter*, Vol. 11, No. 9, August, 1948, pp. 11, 23, illus.

Rigid-Blade Helicopter Undergoing Tests (Rotor-Craft Corp. Tandem). Scholer Bangs. *Aviation Week*, Vol. 49, No. 6, August 9, 1948, pp. 21, 22, 24, 25, illus.

A French Helicopter Development (SE-3101). *The Aeroplane*, Vol. 75, No. 1937, July 23, 1948, p. 108, illus.

New 'Copter' Idea (Seibel Articulated Fuselage). Skyways, Vol. 7, No. 7, July, 1948, p. 35, illus.

Military Gets Close-Up of S-52 (Sikorsky Two-Place Helicopter). *Aviation Week*, Vol. 48, No. 26, June 28, 1948, p. 14, illus.

Sikorsky S-52 Performance. *Aero Digest*, Vol. 57, No. 2, August, 1948, pp. 72, 108.

Flying Shoe (United Helicopters, Inc.). *Aviation Week*, Vol. 48, No. 25, June 21, 1948, p. 25, illus.

Brief description of helicopter powered by two 65-hp. engines driving 30-in. propellers. The pilot remains in a standing position and controls balance by leaning forward or backward.

Sciences, General (33)

MATHEMATICS

The Use of Interlacing Nets for the Application of Relaxation Methods to Problems Involving Two Dependent Variables. D. C. Gilles. With a foreword by W. G. Bickley. *Royal Society of London, Proceedings, Series A*, Vol. 193, No. 1034, July 2, 1948, pp. 407–433, figs. 7 references.

In order to obtain comparable accuracy in all the dependent variables of partial differential equations that are being solved by relaxation methods, the values of some of the variables are determined at the centers of the meshes. This is in effect the use of two interlacing nets. While in cases involving two unknowns both are not determined at the same points, the interlacing nets enable the "coupling" effects to be taken into account more accurately, and the operation involves differential equations of lower order than if one variable is first eliminated between the governing equations. The use of the method is illustrated by the solution by relaxation methods of four representative problems: plane strain with boundary displacements given, stress in a solid of revolution, the conjugate plane-harmonic functions, and the quasi-plane-harmonic equation.

On the Application of Laplace Pairs to the Analysis of Relaxation Curves. H. H. Macey. *Journal of Scientific Instruments*, Vol. 25, No. 7, July, 1948, pp. 251–253, figs. 9 references.

The Solution of Natural Frequency Equations by Relaxation Methods. J. L. B. Cooper. *Quarterly of Applied Mathematics*, Vol. 6, No. 2, July, 1948, pp. 179–183. 2 references.

Electric Circuit Models of Partial Differential Equations. Gabriel Kron. *Electrical Engineering*, Vol. 67, No. 7, July, 1948, pp. 672–684, figs.

A summary of equivalent circuits (electrical models) that have been developed and published by the author during the last few years to represent some of the basic linear partial differential equations of mathematical physics. The networks are valid for all orthogonal curvilinear coordinate systems and represent transient, sinusoidal, or static-field phenomena. Besides the well-known Laplace and Poisson equations, the various models represent the general scalar-potential and vector-potential equations, the compressible fluid flow equations in the hodograph plane, the electromagnetic field equations of Maxwell, the wave equations of Schrödinger, and the basic equations of the theory of elasticity. The networks can be solved by means of an analyzer or by numerical methods initial-value, boundary-value, and characteristic-value problems.

Method of Solving Differential Equations with Constant Coefficients. W. V. Lyon. *Franklin Institute, Journal*, Vol. 246, No. 2, August, 1948, pp. 159–164, figs.

A Norm Criterion for Non-Oscillatory Differential Equations. Aurel Wintner. *Quarterly of Applied Mathematics*, Vol. 6, No. 2, July, 1948, pp. 183–186. 5 references.

A Practical Method for Solving Hill's Equation. L. Brillouin. *Quarterly of Applied Mathematics*, Vol. 6, No. 2, July, 1948, pp. 167–178, figs. 6 references.

The Recent Development in the Electronic Digital Variable Computer. C. Chu. *Chinese Institute of Engineers, Journal*, Vol. 6, No. 1, May, 1948, pp. 58–65.

MECHANICS

Analyzing Graphical Records. Charles E. Balleisen. *Machine Design*, Vol. 20, No. 6, June, 1948, pp. 145–149, figs. 3 references.

To determine the acceleration forces from a time-displacement record it is necessary to ascertain the second derivative of the curve. Point-by-point graphical construction or continuous differentiation with a mechanical differentiator requires two successive operations in which the errors are additive. Numerical differentiation yields any derivative directly by calculations at a limited number of points.

PHYSICS

Magnetization in Perpendicularly Superposed Direct and Alternating Fields. F. J. Beck and J. M. Kelly. *Journal of Applied Physics*, Vol. 19, No. 6, June, 1948, pp. 551–562, figs. 7 references.

Some Units in the Giorgi System and the C.G.S. System. Erik Hallén. (*Kungl. Tekniska Högskola, Handlingar Nr. 6*, 1947.) *Acta Polytechnica* (Stockholm), No. 11 (*Physics and Applied Mathematics Series*, Vol. 1, No. 2), 1947. 44 pp., figs. 20 references. Sw. Kr. 2 : 50.

Stress Analysis & Structures (7)

Deep Ring Analysis. Kuang-Sheng Ching. *Journal of the Aeronautical Sciences*, Vol. 15, No. 9, September, 1948, pp. 531–534, figs. 2 references.

Calculation of the stressing of a thick ring structure, such as that required in the fuselage of a single jet-engine aircraft for the support of the empennage structure. The treatment takes the curved-beam theory and direct and shear deformations into consideration in order to account for variations introduced by the depth effect, which is the ratio of the depth of the ring to its outside radius.

Theory of Elasticity for Thin Circular Cylindrical Shells; Summary of Development and Use in European Structural Engineering. Sigge Eggwertz. (*Kungl. Tekniska Högskola, Handlingar Nr. 9*, 1947.) *Acta Polytechnica* (Stockholm), No. 13 (*Civil Engineering and Building Construction Series*, Vol. 1, No. 2), 1947. 26 pp., diagrs. 31 references. Sw. Kr. 2

A résumé of the mathematical treatments that have been developed for the calculation of the stresses in structural shells, which are based on the theory of elasticity. The Membrane Theory, which neglected all moments and transverse forces, had restricted applicability and was succeeded by Love's general mathematical theory, called the "Flexion Theory." Finsterwalder's solution, the first practicable one for design purposes, was followed by an exact solution by Dischinger which was so difficult that Finsterwalder's original solution or a simplification by Schorer have been the most commonly used. The discovery that the Membrane Theory could be used as an approximation of the differential equations of the Flexion Theory further simplified the required calculations. These are, however, still so time-consuming, even when tables are available and the work has been systematized, that current investigations have been directed toward the developments of methods for particular cases. The most common of these is the Beam Method, which considers circular cylindrical shells as beams supported by gables.

Approximate Solutions for Struts Supported by an Elastic Foundation. Haydon Templeton. *Aircraft Engineering*, Vol. 20, No. 233, July, 1948, pp. 190–193, figs.

Approximate calculation of the stress conditions of a strut supported by an elastic foundation are obtained by the energy method for the cases where the loading is eccentric, where the loading is axial and there is an initial deflexion from an extra-strong element in the elastic support, and for the case where an axially loaded strut is supported on an elastic foundation the elements of which have constant initial deflection. The use of

the energy method to calculate the critical buckling load of an axially loaded strut is also illustrated.

Buckling of Curved Sheets in Compression and Its Relation to the Secant Modulus. E. H. Schuette. **Letter to the Editor.** Edward Adams Richardson. *Journal of the Aeronautical Sciences*, Vol. 15, No. 9, September, 1948, pp. 521, 522.

Sheet-Stringer Panels for Airplane Construction. *U.S. National Bureau of Standards, Technical News Bulletin*, Vol. 32, No. 8, August, 1948, pp. 89–92, illus. 6 references.

A summary of experimental investigations to determine the relation between the buckling behavior of thin metal sheets and their ability to carry axial loads. Aircraft skin panels were tested to determine the effect on the loads carried by the skin of stringer, rivet, and spot-weld spacing, sheet thickness, curvature of the panel, and lateral pressure. The results verified existing theoretical treatments. Experimental study of the instability of unattached stringers gave results in agreement with theory. The theory, however, when extended to stringer-panel structures and applied to light stringers, gave computed values higher than those observed. Current experiments deal with double-skin sandwich-type panels with corrugations or spacers between the skins.

Effect of Longitudinal Stiffeners on the Buckling Load of Long Flat Plates Under Shear. Harold Crate and Hsu Lo. *U.S., N.A.C.A., Technical Note No. 1589*, June, 1948. 46 pp., illus., figs. 6 references.

Curves developed from the theoretical analysis of long flat plate reinforced with any number of longitudinal stiffeners of equal stiffness and equally spaced across the plate give the buckling coefficient for simply supported and clamped edges. Tests of flat plates with a length-width ratio of 8 with one and with two longitudinal stiffeners gave data in fair agreement with the theoretically calculated buckling load.

Buckling of Conical Shells Subjected to Uniform External Lateral Pressure. Frithiof I. N. Niordson. (*Kungl. Tekniska Högskola, Handlingar Nr. 10*, 1947.) *Acta Polytechnica* (Stockholm), No. 14 (*Civil Engineering and Building Construction Series*, Vol. 1, No. 30), 1947. 23 pp., figs. Sw. Kr. 1:40.

A formula is obtained from the theory of thin shells to determine the buckling pressure of frustrums of conical shells of the type used in submarines. It is shown that p_c/E depends on two dimensionless numbers. The result can also be used for buckling beyond the proportional limit.

Tests with Circular Plates. Åke Holmberg. (Recd. March 5, 1946.) (*Ingeniörsvetenskapsakademi, Handlingar Nr. 190*, 1946.) *Acta Polytechnica* (Stockholm), No. 3 (*Civil Engineering and Building Construction Series*, Vol. 1, No. 1), 1947. 110 pp., illus., diagrs., figs. Sw. Kr. 7:50.

A new method for empirical determination of the moment distribution in plates and similar structural elements. The method's main principles are simultaneous measuring of angular displacements in all points necessary for observing the state of deformation and graphical deriving of functions measured. Special apparatus was designed for use with the method. Accuracy has been checked by a special test and found to be satisfactory for most purposes. Nomograms show the results of application of the method to a test series of circular plates with different conditions of load and with large deflections.

Reinforcement of a Small Circular Hole in a Plane Sheet Under Tension. Samuel Levy, A. E. McPherson, and F. C. Smith. *Journal of Applied Mechanics*, Vol. 15, No. 2, June, 1948, pp. 160–168, illus., figs. 6 references.

An analysis of radially symmetrical reinforcements of variable thickness when the load on a plate containing a circular hole is uniform tension in all directions. A plane-stress analysis shows that a reinforcement that crowds most of the material close to the edge of the hole is most effective in reducing the stress concentrations at the hole. The analysis is extended to reinforcement by a doubler plate when the load is tension in one direction only. Tests of doubler-plate reinforcements of various sizes and rivet arrangement indicate that the plane-stress theory gives a good estimate of the state of stress outside the reinforcement and that it may be used for computing median-surface stresses and average elongations of the hole in the specimen, provided that the reinforcement is attached to the sheet by more than one row of rivets.

A Mechanical Analyzer for the Solution of Vibration Problems of a Single Degree of Freedom. E. E. Weibel, N. M. Cokyucel, and R. E. Blau. *Journal of Applied Mechanics*, Vol. 15, No. 2, June, 1948, pp. 146–150, illus., figs. 5 references.

A mechanical-analog type of system employing a torsion pendulum. The varying rotation given to the upper end of the torsion wire represents a variable exciting force acting upon the mass of the system. By the introduction of helical springs between the fixed frame and the pendulum arm, mechanical linkage, and a supplementary torsion wire, various types of elasticity may be simulated: linear plus cubic, pure cubic, negative linear plus cubic, tangent elasticity, and bilinear elasticity. Linear or viscous damping is provided by a conducting metal sector moving in a magnetic field. Periodically varying the tension in the elastic element provides for elasticity variable with time. A generalized solution is obtained on the analyzer giving in dimensionless form the maximum displacements and forces in a system having linear plus cubic elasticity and linear damping caused by a force pulse of constant magnitude and finite duration.

Impact of a Mass on a Damped Elastically Supported Beam. W. H. Hoppmann. *Journal of Applied Mechanics*, Vol. 15, No. 2, June, 1948, pp. 125–136, figs. 17 references.

The differential equation for the forced vibration of a beam and an expression for the coefficient of restitution are developed and used to obtain formulas for deflections of a beam when the force is a function of time and is concentrated at the center of the beam. The method is suitable for studying the effects of elastic foundations and damping on the bending strains and deflections of a simply supported beam. When simply supported on elastic foundations and several modes of vibration are excited, the maximum deflection decreases rapidly and at a much greater rate than the strains as the foundation modulus increases. If the only fundamental mode of vibration is appreciably excited, the strain is proportional to and decreases at the same rate as the deflection. External damping has a rapidly decreasing effect in reducing deflection and strain as the number of the mode increases. Internal damping of the Sezawa type appreciably reduces deflection and strain in the higher modes. When simple support is not elastic and several modes of vibration are excited, a large portion of the deflection is in the fundamental mode, whereas a considerable portion of the strain is in the higher modes. If the beam acts as a single-degree-of-freedom system, the damping factors required to reduce strain and deflections noticeably are relatively large, and the coefficient of restitution increases rapidly as the foundation stiffness increases. Whereas if several modes are excited, the coefficient increases slowly. Increasing the modulus of the elastic foundation reduces the amount of energy absorbed by the structure because the period of vibration of the fundamental of the structure becomes small in comparison with time of contact, which is in accord with the results obtained by Rayleigh for impact between two solid spheres.

Natural Frequency Calculations; Including Forced Vibrations, Beams Under Load, and Torsional Systems. *Product Engineering*, Vol. 14, No. 8, August, 1948, pp. 155, 157, 159, figs.

The Experimental Determination of the Moments of Inertia of Airplanes by a Simplified Compound-Pendulum Method. William Gracey. *U.S., N.A.C.A., Technical Note No. 1629*, June, 1948. 26 pp., diagrs. 7 references.

A compound-pendulum method that eliminates the necessity for locating the center of gravity of the airplane by direct measurement. The pendulum length is found by measuring the difference between two suspension lengths and solving the equations for the two suspensions simultaneously. Accuracy is equal to that of the standard pendulum method. The simplified method permits a reduction in experimental technique, test apparatus, and time required to perform the tests.

The Nature of the Distortion of Swept-Back Wings. G. T. R. Hill. **Correspondence.** Albert Rose. *Royal Aeronautical Society, Journal*, Vol. 52, No. 451, July, 1948, pp. 481, 482, figs.

The Aerodynamic Forces on an Oscillating Flap at Supersonic Speeds. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 15, No. 9, September, 1948, pp. 565–568, figs. 3 references.

In a previous paper by the author, the Green's function for the pressure on an airfoil in a supersonic stream due to an arbitrary harmonic velocity distribution was used to find the lift and midchord pitching moment caused by plunging and pitching and to find the response of an airfoil to a sudden change in angle of attack or flap deflection or its response upon entering a sharp-edged gust. The results are extended to include the forces on an oscillating flap which are the result of its own motion and

the motions of the airfoil as a whole. The numerical results for M, 1.2, 1.4, 1.6, and 2.0, are given as plots of both the real and the imaginary parts of the coefficients for a range of the reduced frequency of 0 to 1.4.

An Engineering Evaluation of Flutter and Other Aeroelastic Problems at Transonic and Supersonic Speeds. Benjamin Smilg. *U.S., Air Force, Air Technical Intelligence, Technical Data Digest*, Vol. 13, No. 14, July 15, 1948, pp. 9–18, figs. 7 references.

Mathematical investigations of flutter, the reversal of control surface effectiveness, airfoil divergence, and gust loads, and experimental data indicate that classical flutter is likely to be more easily prevented at supersonic than at subsonic or transonic speeds. The determining factor for the torsional rigidity of supersonic wings with ailerons will probably be the reversal of control-surface effectiveness caused by airfoil twist, which is likely to be less severe for moderate supersonic speeds at extremely high altitudes than for subsonic speeds at low altitudes. Divergence is not likely to be critical at supersonic speeds for airfoils with trailing-edge control surfaces, and the decrease in the torsional rigidity required with increasing altitude may permit the time history of velocity and altitude to be so chosen for an aircraft that the torsional rigidity for take-off or launching speeds will be adequate during supersonic flight. In order to prevent flutter and other undesirable aeroelastic phenomena at transonic and supersonic speeds, airfoils and control surfaces should have high torsional rigidity. Control systems for surfaces and tabs should have stiff irreversible mechanisms and/or damping devices close to the control surfaces.

What Kind of Information Does Brittle Coating Give? I, II. A. J. Durelli. *Product Engineering*, Vol. 19, Nos. 6, 7, June, July, 1948, pp. 86–91; 133–136; figs. 20 references.

I. An analysis of the nine typical isostatic and isoenstatic patterns in brittle coatings which may be obtained with various combinations of stresses. Formulas for the principal stresses and strains are tabulated for the different cases. The accuracy of the continuous isostatics obtained by this method is higher than that obtained by photoelastic or strain-gage methods because point-to-point graphic interpolation is not required and the data are not restricted by gage length. **II.** The brittle-coating pattern of a ring under diametral compression is analyzed to determine stress distribution. The results are in good agreement with values obtained from photoelastic determinations. Includes discussion of the variation in stress distribution with change in loading and the variation in values for the different quadrants caused by eccentricity of the load.

"Frozen Stress" Photo-Elasticity Using Phenol Resins Wrapped in Protecting Foils. E. Mönch. (*Kunststoffe*, Vol. 37, No. 9, September, 1947, pp. 181–189.) *The Engineers' Digest*, Vol. 5, No. 5, July, 1948, pp. 255–257, figs. 5 references.

Tests of Six Types of Bakelite-Bonded Wire Strain Gages. William R. Campbell. *U.S., N.A.C.A., Technical Note No. 1656*, July, 1948. 29 pp., diagrs., figs. 2 references.

Tests were made on six types of bakelite-bonded wire strain gages which included representative gages utilizing advance and isoelastic strain-sensitive wires. The calibration factors for the ten gages of a given type which were tested differed from the average factor for that type by not more than 1.6 per cent. The calibration factor decreased for all gages when the temperature was increased to 170°C., and for one type of gage a reduction of 3 to 9 per cent was observed at 140°C. The changes in gage resistance due to the electric power dissipated by the gage corresponded to maximum indicated strains of −520 microin. per watt for the advance gages and 5,400 microin. per watt for the isoelastic gages. All gages showed appreciable sensitivity to changes in temperature. This sensitivity was so nearly uniform for gages of the same type that gages picked at random would compensate in unit change in gage resistance within 0.02×10^{-4} per °C. for gages using advance wire and within 0.15×10^{-4} per °C. for gages using isoelastic wire.

An Optical Rectangular Rosette Extensometer for Large Strains. K. H. Swainger and J. Twyman. *Journal of Scientific Instruments*, Vol. 25, No. 6, June, 1948, pp. 187–189, illus., diagrs. 7 references.

An optical extensometer to measure strains simultaneously in two orthogonal directions and in a third at 45° to the other two. In order to measure extremely large strains, the knife edges of the instrument can be reset to their initial positions when the effective range of the instrument has been covered. The scale of 100 cm., covered without resetting the instrument, corresponds to a strain 0.125 in. per in. per in. gage length. Each of the legs is a selfcontained extensometer. A long optical path and a telescope to read the scale provide the sensitivity requisite for the calibration of resistance-wire strain gages to be used in connection with the investigation of postyield strains and their interpretation into plane stresses.

Flexural Fatigue Strength of Steel Beams. Wilbur M. Wilson. *Illinois, University, Engineering Experiment Station, Bulletin Series No. 377*, January 22, 1948. 32 pp., diagrs. $0.20.

Influence Lines for Horizontally Curved Fixed-End Beams of Circular-Arc Plan. Robert B. B. Moorman and Manford B. Tate. *University of Missouri, Bulletin*, Vol. 48, No. 26, October 10, 1947. 39 pp., figs.

Stresses in a Uniformly Loaded Circular-Arc I-Beam. Robert B. B. Moorman. *University of Missouri, Bulletin, Vol. 48, No. 27, Engineering Series No. 36*, October 20, 1947. 32 pp., diagrs., figs. 5 references.

Investigation of Bridge Impacts with a Mechanical Oscillator. C. T. West. *Ohio, State University, Engineering Experiment Station, Bulletin No. 132*, July, 1948. 54 pp., illus., figs. 13 references. $0.75.

Thermodynamics (18)

An Investigation of Aircraft Heaters. XXVI—Development of a Sensitive Plated-Type Thermopile for Measuring Radiation. L. M. K. Boelter, E. R. Dempster, R. Bromberg, and J. T. Gier. *U.S., N.A.C.A., Technical Note 1450*, July, 1948. 66 pp., figs.

An analysis of the factors determining the power efficiency or radiation thermopiles in which the receivers are either parts of the conductors themselves, coatings, or other electrically insulating materials in intimate contact with these conductors. Criteria of maximum power efficiency for silver-constantan plated-type of thermopiles were calculated. Test data obtained with thermopiles so constructed agree with predicted performance. An approach to maximum power efficiency can be realized independently of the resistance of the thermopile over a wide range. Within this range, maximum sensitivity with a particular galvanometer or other measuring or controlling device can be obtained by designing simultaneously for maximum power efficiency and for whatever value of resistance is required to produce proper damping, to provide maximum power transference, or to satisfy other criteria. Calculations show that in theory it is possible to obtain with silver-constantan 80 per cent of the voltage produced under equivalent conditions by an ideal thermopile of the same type in which the conductors lose no heat by radiation. The appendixes contain a review of literature on radiation-measuring thermopiles, the derivation of expressions for computing junction temperatures, derivation of expression for voltage loss due to currents circulated in the sheath and core of plated conductors, comparative efficiency of thermopiles analyzed in the report and thermopiles of the Johansen type, the method used to construct plated silver-constantan thermopiles, and comments on the design of thermopile radiometer housings.

An Investigation of Aircraft Heaters XXVII—Distribution of Heat-Transfer Rate in the Entrance Section of a Circular Tube. L. M. K. Boelter, G. Young, and H. W. Iversen. *U.S., N.A.C.A., Technical Note No. 1451*, July, 1948. 53 pp., illus., diagrs., figs. 6 references.

Experimental data on the variation of the point unit thermal conductance in the entrance section of a circular tube are presented for 16 different flow conditions of the entering air. Results are compared with values calculated from existing analytical solutions. The average (integrated mean with length) unit thermal conductance is also calculated for eight entering-air conditions and is compared with values resulting from analytical methods. In many cases the experimental values are appreciably higher than those derived from equations that are based on overall data taken on long pipes.

Water-Borne Aircraft (21)

Tank Tests of a $^1/_{10}$-Size Model of a Hypothetical Flying Boat with a Hull Length-Beam Ratio of 9.0. Marvin I. Haar. *U.S., N.A.C.A., Technical Note 1648*, July, 1948. 47 pp., illus., figs. 14 references.

For a given gross weight, if the length²-beam product is maintained constant, the size of a flying-boat hull and, consequently, the aerodynamic drag can be reduced by increasing the length-beam ratio from 6 to 9 with no serious adverse hydrodynamic stability or resistance characteristics that can be attributed solely to the increased length-beam ratio of the hull. The effect of such hull parameters as gross load, depth of step, angle of afterbody keel, and length of afterbody on the trim limits of stability, range of position of the center of gravity for stable take-off, landing stability, and power-off total resistance is approximately the same for a model with a length-beam ratio of 9 as for hulls with a length-beam ratio of 5 or 6.

A Generalized Theoretical Investigation of the Hydrodynamic Pitching Moments Experienced by V-Bottom Seaplanes During Step-Landing Impacts and Comparisons with Experiment. Benjamin Milwitzky. *U.S., N.A.C.A., Technical Note No. 1630*, June, 1948. 62 pp., diagrs., figs. 5 references.

Derives dimensionless variables which define hydrodynamic pitching-moment and center-of-pressure variations during seaplane impacts. Theoretical time histories of pitching moment and center of pressure, as well as solutions for the conditions that exist at the particular instants of maximum acceleration, maximum moment, maximum draft, and zero draft during rebound are presented. Theoretical results agree well with experimental data.

Have We Missed the Flying Boat? Edgar H. Bauman. *Air Transportation*, Vol. 12, No. 5, May, 1948, pp. 10–12, 32, 33, illus.

A discussion of the advantages to be obtained by using flying boats as commercial passenger and cargo transports. The U.S. Navy has operated the Martin Mars at a lower total cost per mile than that for land transport aircraft because of its high pay load. Sufficient inland water is available to permit the establishment of transcontinental routes.

"Petulant Porpoise" Tests Hulls; Interchangeable Hull is Feature of Research Plane Used to Try Out New Designs for Flying Boats. *Aviation Week*, Vol. 49, No. 2, July 12, 1948, p. 15, illus.

Selling Float Flying. *Aviation Maintenance & Operations*, Vol. 10, No. 3, August, 1948, pp. 58, 59, illus. Revenue possibilities from water operations, publicity for seaplane operations, and seaplane facilities.

How to Fly Floats. George B. Post. *Canadian Aviation*, Vol. 21, No. 8, August, 1948, pp. 18, 19, 46, 47, illus., figs.

Wind Tunnels (17)

Experimental Investigation of the Jet-Boundary Constriction Correction for a Model Spanning a Closed Circular Tunnel. M. Tucker and M. D. Rousso. *U.S., N.A.C.A., Technical Note No. 1638*, June, 1948. 30 pp., illus., diagrs., figs. 6 references.

An experimental evaluation of the velocity increment at a large model spanning a circular wind tunnel which is caused by the accelerating effect of the walls on the flow past the model at zero lift and the effect of the induced curvature of flow arising from lifting action at various angles of attack. Theoretical constriction corrections for the component parts of the model did not check the experimental values. The overall theoretical constriction correction, however, could be brought into agreement with the experimental value by the use of the principle of superposition. The effect of the induced curvature of flow on the lift according to theory for a flat plate in a two-dimensional tunnel was in qualitative agreement with the experimental results.

Supersonic Nozzle Design. J. Conrad Crown. *U.S., N.A.C.A., Technical Note No. 1651*, June, 1948. 34 pp., diagrs., figs. 10 references.

A summary of the physical characteristics of two-dimensional flow in nozzles to show the basic factors that determine the design of wind-tunnel test sections that have parallel supersonic flow. Three methods for establishing the initial and terminal curves, Busemann's, Puckett's, and Foelsch's, are outlined. The velocity distribution in a test section can be determined by an analysis of the nozzle configuration. The flow field may be constructed analytically or graphically, but the supersonic protractor, on which the stream angle and the expansion angle can be set directly, provides the simplest and most direct method.

Investigation of Some Factors Affecting Comparisons of Wind-Tunnel and Flight Measurements of Maximum Lift Coefficients for a Fighter-Type Airplane. Don D. Davis, Jr., and Harold H. Sweberg. *U.S., N.A.C.A., Technical Note No 1639*, June, 1948. 32 pp., illus., figs. 5 references.

The effects of time rate of change of angle of attack, idling propeller operation, and Reynolds Number on the maximum lift coefficient of a single-engined fighter-type airplane were investigated. Flight-test measurements of the maximum lift coefficient of the same airplane were also made, and the results are compared with the wind-tunnel data. Two unusual wind-tunnel corrections, one for a spanwise variation of the dynamic pressure and the other for the chordwise variation of the jet-boundary induced downwash, must be made for proper evaluation.

Instrumentation Conquers the Sonic Barrier. M. F. Behar. *Instrumentation*, Vol. 21, No. 6, June, 1948, pp. 505–509, illus., diagrs.

Comment on the progress of supersonic research in the field of ballistics and its final unification both in experiment and instrumentation with aerodynamic investigations at subsonic speeds. The facilities at the Ballistic Research Laboratories of the Army Ordnance Department include indoor free-flight testing ranges, a missile ballistic range, and full-scale free-flight ranges. The intermittent supersonic wind-tunnel facilities of the laboratories were expanded by the installation of a fixed-throat continuous-operation tunnel with interchangeable nozzles that could operate at subsonic speeds as well as at Mach 1.72. The most recent wind tunnel to be put into operation is the flexible-throat tunnel that has a range from subsonic to Mach 4 and a range in Reynolds Numbers from about 10 to 1. Diagrammatic layout of the installation and illustrations of the instrumentation are included.

NACA Shows Ames Laboratory Progress. Robert Hotz. *Aviation Week*, Vol. 49, No. 4, July 26, 1948, pp. 11, 12, illus.

Changes of Address

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Aeronautical Reviews

Books

AERODYNAMICS

Birds on the Wing. John Barlee. London. Collins Publishers, 1947. 128 pp., illus., diagrs. 12*s*. 6*d*.

A brief introduction to the aerodynamics of bird flight is followed by 94 excellent photographic studies of the flight of 17 varieties of birds native to Ireland. The accompanying detailed notes on the flying abilities and habits of the birds are useful to the student of the mechanics of bird flight as well as to the naturalist. A brief note on equipment and techniques of bird photography concludes the book.

AIRPLANE DESIGN & DESCRIPTION

Fowler Flaps for Airplanes; an Engineering Handbook. Harlan D. Fowler. Los Angeles, Wetzel Publishing Co., Inc., 1948. 90 pp., illus., diagrs., figs. $6.00.

In presenting this compilation of technical data on the principles, characteristics, and applications of the Fowler flap, the author has drawn from his own knowledge of his invention and from the results of theoretical investigations and experimental tests made by the N.A.C.A. and many aircraft manufacturers. A brief historical introduction traces the development of the Fowler flap from the first searches for a device to increase the lifting power of a wing to its present level of evolution. The Fowler flap has been adapted to 30 aircraft, a number that will be increased as new airplanes are designed and produced. The titles of the nineteen technical sections show the subject matter and scope of the book: Principle of the Fowler Flap, ΔC_{Lmax}. Obtained with Various Types of Flaps, Variation of ΔC_{Lmax}. with Flap Span, Effect of Flap Location on Airplane Characteristics, Scale Effect and Mach Number on C_{Lmax}., Aspect Ratio and Profile Drag, Determination of Horizontal Tail Area for Fowler Flap Installations, Effect of Fowler Flaps on Take-Off Distances, Stalling and Landing Speed, Stress Analysis and Structural Design, Stress Analysis Procedure, Track and Carriage Design, Design of Track and Bearings, Cables and Push-Pull Controls, Flap and Wing Trailing Surface, Weight of Fowler Flap Installations, Application of Engine Power to Special Flight Conditions, Lateral Control for Full Span Flaps, and Post-War Developments. Graphs and diagrams constructed from calculated and experimental data form an integral part of the text and number almost 50. There are over 40 illustrations showing the application of Fowler flaps in actual aircraft. There is a list of 60 reports (issued by the N.A.C.A. and various companies), which are referred to in the text, and an index of topics. The book is a handy reference for engineers and should prove useful to others interested in Fowler flap practice.

AIRPORTS & AIRWAYS

Rules of the Air and Air Traffic Control. RAC Division, Third Session, Final Report, April 20th–May 20th, 1948. (Document No. 5500-RAC/5666.) Montreal, International Civil Aviation Organization, May, 1948. 210 pp. $0.75.

The Division's recommendations for international standards and recommended practices and amendments to previously established procedures form the first part of this report. Subjects for further study, research, and development and various committee reports are included in the final report of this session.

ATOMIC ENERGY

Atomic Energy. Karl K. Darrow. New York. John Wiley & Sons, Inc., 1948. 80 pp., illus., diagrs. $2.00.

These Norman Wait Harris lectures of 1947, delivered at Northwestern University, are designed to present the basic facts most pertinent to the transformation of energy of rest mass into energy of motion and energy of heat for those whose special fields of interest are outside the field of physics.

AVIATION MEDICINE

A Bibliographical Sourcebook of Compressed Air, Diving and Submarine Medicine. Ebbe Curtiss Hoff. Washington, U.S. Govt. Printing Office, 1948. 382 pp. $2.50.

About 3,000 references are given, classified under twelve main headings and 221 subheadings, referring to more than 600 journals. The listing under each subject and each subdivision is preceded by a summary of the existing knowledge on that subject, amounting in most cases to a detailed abstract of the literature. An author index and a subject index are included.

ELECTRONICS

Principles and Methods of Telemetering. Perry A. Borden and Gustave M. Thynell. New York, Reinhold Publishing Corporation, 1918. 230 pp., illus., diagrs. $4.50.

This is the first book in English to undertake the description of the existing apparatus used in the reproduction at a convenient location of measurements made at a remote point. The first eight chapters deal with current or conductance systems, voltage systems, frequency systems, position systems, and impulse systems of telemetering, followed by chapters on interconnecting circuits and channels, carrier current, coordinating and integrating, remote reading of dials and registers, and selection and application of telemetering systems. Hydraulic and pneumatic systems are discussed in a brief appendix. Other appendixes include a bibliography of 79 references arranged by subject, a list of 14 registered names and trade marks, and a list of about 400 U.S. and foreign patents.

Design of Crystal Vibrating Systems for Projectors and Other Applications. William J. Fry, John M. Taylor, and Bertha W. Henvis. New York, Dover Publications, Inc., 1948. 182 pp., charts. $3.50.

This is a revised edition of a report published in 1945 by the U.S. Office of Technical Services (PB 22,410), having been undertaken under the authorization of the Sonar Design Section of the Bureau of Ships. A detailed study is presented of crystal vibrating systems and design procedures essential to the design of projectors. The performance of other piezoelectric devices such as wave filters, blast gages, and accelerometers can also be treated by following the procedures presented for projectors. The first 149 pages contain curves based on general piezoelectric relations. The mathematical analysis and derivations of the expressions used in constructing the curves are given in the second part. Units, definitions, symbols, conventions, and tables and graphs of physical constants are given in appendixes.

FLIGHT & GROUND TRAINING

Aeronautical Training. Charles A. Zweng. North Hollywood, Calif., Pan American Navigation Service, 1948. 444 pp., illus.

This textbook is designed for use in preparing for private or commercial pilot examinations and for use in schools teaching flight and ground instruction. It was last revised in 1947. Navigation, meteorology, aircraft, aircraft engines, and *Civil Air Regulations*, including air traffic rules, are covered. New Material is included on theory of flight, meteorology, navigation, and flight maneuvers required in the new examinations.

Radio and Instrument Flying. Charles A. Zweng and Allan C. Zweng. North Hollywood, Calif., Pan American Navigation Service, 1948. 355 pp., illus., diagrs. $4.00.

This textbook, last revised in 1947, is designed as an aid in preparation for Government examinations for the instrument rating. This revision takes into account changes in the *Civil Air Regulations* and the new multiple-choice examinations, including the use of maps. Material necessary to pass the examination for radio telephone operator's permit is included.

Flight Instructor. Charles A. Zweng. 6th Ed. North Hollywood, Calif., Pan American Navigation Service, 1948. 335 pp., illus., diagrs.

This textbook, designed for use in preparing for the Government examinations for flight instructor rating, was last revised in 1947. Examples of new examination questions and a typical examination of the new multiple choice type are included.

HISTORY

The AAF Against Japan. Vern Haughland. New York, Harper & Bros., 1948. 515 pp., illus. $5.00.

This detailed history covers the Pacific war from Pearl Harbor to the American occupation of Japan. While the author describes it as an informal history, he received full cooperation from the Personal Narrative Division of Air Forces Information and Public Relations, in New York and Washington, including access to its files and assistance from a three-man research team. Interviews and correspondence with high Air Force spokesmen and the author's notes and observations as a news reporter in the Pacific area throughout the war were used to supplement the material gathered from documents. A good index of personal and place names, as well as subjects, is included.

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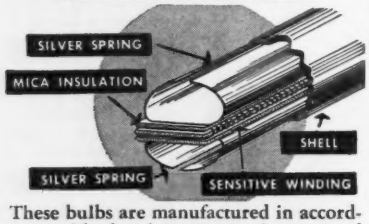

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MACHINE ELEMENTS

Design of Machine Elements. M. F. Spotts. New York, Prentice-Hall, Inc., 1948. 402 pp., illus., diagrs. $6.65.

The first chapter is a 41-page review of the fundamental principles of strength of materials, and the following two chapters deal with Stress Concentration and Repeated Loading, and Theory of Torsion. The next nine chapters deal with springs; screws; belts; brakes and clutches; welding and riveted connections; ball and roller bearings; spur gears; and helical, bevel, and worm gears. A chapter on miscellaneous machine elements is included, such as ribbed castings, flywheels, roller chains, and gaskets and also deals with statically indeterminate problems, impact, and shrink fits. A chapter on lubrication is included, and the book ends with chapters on Dimensioning and Details and Engineering Materials. A large number of problems is supplied, and there are 200 references given at the ends of chapters. The author is a professor of machine design at Northwestern University.

MATERIALS

Materials Handbook; an Encyclopedia for Purchasing Agents, Engineers, Executives, and Foremen. 6th Ed. George S. Brady. New York, McGraw-Hill Book Co., Inc., 1947. 831 pp. $7.00.

This sixth edition of this well-known reference book, last revised in 1944, contains more than 600 additional substances in its index, and the appendix of tables has been expanded into a 58-page Part II, containing basic economic data not previously included.

Copper As an Alloying Element in Steel and Cast Iron. C. H. Lorig and R. R. Adams. New York, McGraw-Hill Book Co., Inc., 1948. 213 pp., illus., diagrs. $3.00.

This book is intended to bring up to date the compilation of data from the technical literature started by Gregg and Daniloff in their *Alloys of Iron and Copper*, New York, 1934, and to serve as a readily available reference source on ferrous materials containing small amounts of copper. Cast and wrought copper steels, copper cast iron and malleable iron, weldability and corrosion resistance of copper steels, and the constitution and structure of the types of alloys discussed are included. A bibliography of 102 items is included. The authors are with the Battelle Memorial Institute.

NAVIGATION

Practical Astronomy. 4th Ed. George L. Hosmer and James M. Robbins. New York, John Wiley & Sons, Inc., 1948. 355 pp., illus., diagrs. $4.50.

The last previous revision of this textbook was published in 1931. New material and problems are included, and the book has been rewritten throughout. While the principal aim is to supply a textbook for the civil engineer and surveyor, the first part on fundamentals is common to both navigator and surveyor.

OPERATIONS, COMMERCIAL

Air Mail Study. (Document No. 5348-AT/654.) Montreal, International Civil Aviation Organization, Air Transport Committee, April, 1948. 114 pp. $0.50.

The primary purpose of this document is to facilitate an expression of the collective views of member states on those aspects of international air mail that are primarily of economic significance. Statistical data are included throughout. The machinery of finance, relation to the air line, effect of changes in the rate structure, and international aspects of air-mail carriage by a country's own air lines and by foreign air lines, air-mail priority, cooperation between air lines and postal administrations, and the growth of the international concept are discussed.

(*Continued on page 93*)

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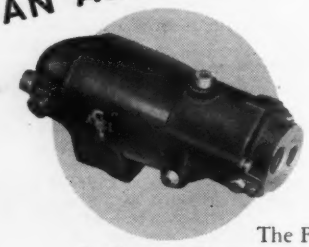

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News of Members

(*Continued from page 15*)

Robert J. Lang has changed his position from Chief Engineer of the Aero Industries Technical Institute of Oakland Municipal Airport to Chief Engineer of Transocean Air Lines, also at Oakland Airport.

Joseph T. Lester, Jr., is employed at the Supersonic Laboratory of Massachusetts Institute of Technology, where he has been since July.

Melvin Lindner resigned as Assistant Research Engineer at Instrument Development Laboratories to become Instructor in Aeronautical Engineering in Rhode Island State College.

R. C. Loomis resigned from Trans World Airline to become Director, Flight Test & Research, Flight Department, Consolidated Vultee Aircraft Corporation (San Diego).

R. Duncan Luce is a graduate student at Massachusetts Institute of Technology.

Harold C. Martin has been at University of Washington as Associate Professor of Aeronautical Engineering since March, 1948.

Andrew I. McKee, Jr., is an Engineering Trainee at Willis Air Service, Teterboro, N.J.

Stanford E. Neice is an Engineer at Cornell University. He was appointed in September.

Alexander J. Pappas left Sikorsky Aircraft to join Republic Aviation Corporation as Structural Engineer.

Donald H. Price is Aerodynamicist B in the Flutter Section of Northrop Aircraft, Inc., and now lives in Beverly Hills, Calif.

Herbert Rose has been with Northrop Aircraft, Inc., as Structures Test Engineer in the Engineering Test Section since April, 1947. He had been with Douglas Aircraft, Santa Monica, in Strength Test Group with similar duties prior to joining Northrop.

Ernest W. Schlieben is a department head in charge of development and research at the Naval Air Development Station, Radome Section, Aircraft Electronics & Electric Laboratories.

Wesley W. Smith is at Texas A & M College as Assistant Professor. He was appointed September 1.

Robert E. Street was named Associate Professor of Aeronautical Engineering at University of Washington in September.

A. G. Thomas has been with Pan American World Airways as Maintenance Training Supervisor in Miami since 1941.

Paul Tuntland is Copilot on a Trans World Airline Constellation.

Louis R. Viggiano is Project Engineer P-4 at the Wright-Patterson Air Force Base doing wind-tunnel testing.

Henry G. Webb, Jr., is a student at Massachusetts Institute of Technology, Cambridge, Mass.

Jerome Weissman has been with Consolidated Vultee Aircraft Corporation since June, 1948 as Flight Test Engineer.

Edward C. Wells, formerly Vice-President—Chief Engineer, Boeing Airplane Company, was promoted to Vice-President—Engineering at a meeting of the firm's Board of Directors.

Austin Wickwire, former Design Engineer on electromechanical actuators with AiResearch Manufacturing Company, has joined Lockheed Aircraft Corporation (Plant A) as Power Plant Design Engineer.

David T. Wilson, Jr., is with McDonnell Aircraft Corporation, where he has been a Draftsman since July, 1948.

George W. Wilson, who is an Associate Fellow of the Royal Aeronautical Society, is Senior Experimental Officer in the Directorate of Aircraft Research and Development, British Ministry of Supply, Edmonton, Alberta, Canada.

Lee Winograd is with the Ames Aeronautical Laboratory, N.A.C.A., in Flight Research.

Ernest L. Zeiller is an Aerodynamicist with Consolidated Vultee Aircraft Corporation (Fort Worth).

Rudolph J. Zoudlik is Engineering Draftsman A with Piasecki Helicopter Corporation, Morton, Pa.

Early Bird Host: *Frank Tichenor (left), publisher of Aero Digest, and host at the Early Birds' Annual Banquet in Cleveland, talks over Air Force-Navy matters with Rear Adm. Daniel V. Gallery, Jr., a chief speaker at the meeting.*

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to the Associate Fellow Grade

Kirste, Leo, Ing. Dr., President & Prof., Light Structures, Technical University of Vienna.

Transferred to Associate Fellow Grade

Murphy, Joseph Nathaniel, M.S. in Ae.E., Capt., U.S.N.; Dir., Piloted Aircraft Div., Bureau of Aeronautics, Navy Dept.

Elected to MEMBER Grade

Aguer, Jean Andre, Engineer, Air France.

Arnold, Fred G., Chief Engineer, A. & R. Dept., U.S. Naval Air Station (San Diego).

Bayliss, L. J. G., Production Standards Designer, Atlas Works, Messrs. Fielding & Platt, Ltd. (Engineers).

Bryant, Paul Murray, B.S.M.E., Engineer, Power Plant Installation, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Carson, William Thomas, Jr., B.S., Aerodynamicist, Northrop Aircraft, Inc.

Crone, Robert M., B.S., Aerodynamicist "B," North American Aviation, Inc.

Elebash, Albert Parrish, B.S. in Ae.E., Asst. Sales & Service Mgr., The B. G. Corp.

Matthews, Ralph Walter, B.S. in M.E. & Ae.E., Design Engineer, Consolidated Vultee Aircraft Corp.

McKinney, Wilbur Thomas, A.B., Structures Engineer, Consolidated Vultee Aircraft Corp.

Mossberg, Olof Ludvig, B.S. in Engrg., Aerodynamicist, Saab Aircraft Co.

Muirhead, Vincent U., B.S., Lt. Cmdr., Naval Aviator, U.S.N.

Sawyer, William T., S.M., Lt. Cmdr., U.S.N., Bureau of Ships, Navy Dept. (Washington, D.C.).

Smith, Josiah E., A.E. in Ae.E., Asst. Director of Southern California Cooperative Wind Tunnel and Cal Tech. 10-Ft. Wind Tunnel, California Institute of Technology.

Truran, John W. J., Principal Scientific Officer & West Coast Representative, British Joint Services Mission.

Wood, Reginald Thomas, Chief Technician, Pest Control, Ltd. (England).

Yu-Pei, Ling, B.Sc., Special Lecturer, National Yunnan University (China).

Zebb, Keirn, A.E., Chief of Aerodynamic Research, Southern California Cooperative Wind Tunnel, California Institute of Technology.

Transferred to MEMBER Grade

Bird, Ronald Edward, Chief Designer, Auster Aircraft, Ltd. (Rearsby Aerodrome).

Brannon, Ward, Ae.E., Sr. Flight Test Engineer, Data Reduction Group, The Glenn L. Martin Co.

Clark, Robert John, M.S. in Ae.E., Supervisor, Fuselage Design, North American Aviation, Inc.

Dorrance, William Henry, M.S. in Ae.E., Research Assoc. in Aerodynamics, Engineering Research Institute, University of Michigan.

Neice, Stanford Emery, B.A.E., Research Asst., Graduate School of Aero. Engineering, Cornell University.

Elected to Associate Member Grade

Curry, James, Warrant Officer Engineer, Royal Australian Air Force.

Darrow, Richard William, B.A., Director of Public Relations, The Glenn L. Martin Co.

Felio, Harold G., Vice-President, Marine Aircraft Corp.

Hopgood, Roy Caldwell, S.M. in E.E., Patent Lawyer, Mitchell & Bechert.

Hutchinson, Berkeley W. B., Technical Engineering Sales Representative, Marman Products Co., Inc.

Michael, Fernand A., Ground Engineer 1, Air-India, Ltd.

Smith, LeRoy F., Lt., Weight & Balance Officer & Test Pilot, Pilotless Aircraft Unit, U.S.N., N.A.M.T.C. (Pt. Mugu).

Elected to Technical Member Grade

Coles, Donald, M.S. Ae.E., Research Asst., California Institute of Technology.

Dye, Fulton Eugene, Jr., B.S., Research Analyst "B," Ordnance Aerophysics Lab., Consolidated Vultee Aircraft Corp.

Estill, Harold W., B.S.M.E., Part-time Design Engineer, Aero. Research Lab.,

and Instructor, Dept. of Mech. Engineering, University of Kentucky.

Havard, Emlyn George, Aerodynamicist, Rolls-Royce, Ltd. (England).

Koch, George W., B.S., Aerodynamicist, The Glenn L. Martin Co.

McCurdy, William James, B.S. in Ae.E., Aero. Research Engineer, Research Div., United Aircraft Corp.

Mobsby, Peter George, Airframe Design Technician, Design Stress Office, Bristol Aeroplane Co.

Paster, Donald Lee, B.S., Test Engineer, AGT Development, General Electric Co.

Steffen, John W., B.S., Draftsman, United Air Lines, Inc.

Typaldos, Z. A., B.S., Research Engineer, University of California.

Transferred to Technical Member Grade

Angeloro, Vincent C., Student, Academy of Aeronautics.

Barwinkel, Werner Paul, B.S. in Ae.E., Resident Engineer, American-La. France Foamite Corp.

Baum, Joseph Vernon, B. of Ae.E., Jr. Design Engineer, Airplane Div., Curtiss-Wright Corp.

Bauman, John R., B.S. Ae.E., Jr. Engineer, Airplane Div., Curtiss-Wright Corp.

Beilock, Milton, B.A.E., Aero. Research Scientist P-2, N.A.C.A. (Langley Field).

Berry, Joann, B.S.A.E., Technical Documents Cataloger, Langley Mem. Aero Lab., N.A.C.A.

Bruns, Erwin, B.A.E., Detail Layout Draftsman, Chance Vought Aircraft Div., United Aircraft Corp.

Buhman, Charles, Jr., B. of Ae.E., Sr. Detailer, McDonnell Aircraft Corp.

Bull, Gerald Vincent, B.A.Sc., Stress Analyst, A. V. Roe Canada, Ltd. (Canada).

Campbell, George A., B.S. in Ae.E., Graduate Student, Purdue University.

Carner, Harold Arthur, Jr., B. of Ae.E., Aero. Engineer P-1, Muroc Flight Test Unit, N.A.C.A.

Charak, Mason Thomas, M.S. in Ae.E., Aero. Research Scientist P-2, N.A.C.A. (Langley Field).

Congdon, Elmer S., B.S., Aero. Engineer P-3, Flight Test, N.C.V., N.A.T.C. (Patuxent River).

Cotter, Harry Norman, B.S. in M.E., Aero. Engineer, Advance Design Group, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Crissey, Jackson Robert, B.S. in M.E. (Aero.), Jr. Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

de Bruyn, Herbert G., B.S.Ae.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Donegan, James J., Jr., M.S. in Ae.E., Aero. Research Scientist, N.A.C.A. (Langley Field).

Dubell, Bert W., B.S. Ae.E., Stress Analyst, McDonnell Aircraft Corp.

Fowler, John R., B.S., Captain-Pilot, U.S.A.F.

Garrison, Walter Raymond, Jr., B.S. in Ae.E., Graduate Student and Instructor, University of Kansas.

Geisinger, Roy Eugene, B.A.E., Research Engineer's Asst., McDonnell Aircraft Corp.

Glotfelter, Hal Cooper, B.A.E., Jr. Aerodynamicist, The Glenn L. Martin Co.

Goodall, William Alexander, B.A.Sc., Flight Lt., Aero. Engineering Officer, R.C.A.F. (Camp Borden, Canada).

Graves, James A., B.S., Flight Test Engineer, McDonnell Aircraft Corp.

Greene, Ford Joseph, B.S. in Ae.E., Sr. Detailer, McDonnell Aircraft Corp.

Hess, Gene Victor, A.A. in Ae.E.

Heyman, Donald F., B.S. Ae.E., Structural Engineer, U.S. Corps of Engineers, Rock Island, Ill.

Hildebrand, Robert Bruce, S.M., Jr. Engineer, Research Group, Boeing Airplane Co. (Seattle).

Hoskin, Harold E., B.Ae.E., Jr. Engineer, Wright Aero. Corp.

Ignatowski, Alvin F., B.Ae.E., Engineering Technician, Lockheed Aircraft Corp.

Jacobson, Robert Hebert, B. of Ae.E., Aerodynamicist, North American Aviation, Inc.

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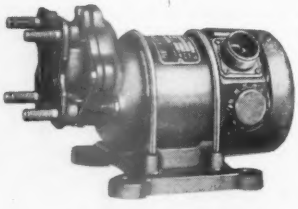

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Karraker, Connard F., B.S., Stress Analyst, Douglas Aircraft Co., Inc.

Keller, Robert B., B.S. in Ae.E., Detail Engineer, Boeing Airplane Co. (Wichita).

Keller, Robert H., B.S. Ae.E., Jr. Design Engineer, Boeing Airplane Co. (Seattle).

Kolman, Frederick A.

Krause, Lloyd N., B.Ae.E., Aero. Engineer, N.A.C.A. (Cleveland).

Lazar, James, B. of Ae.E., Aero. Engineer, Flight Propulsion Research Lab., N.A.C.A. (Cleveland).

LeFors, Roy Clayton, A.A. in Ae.E., Engineer, Winterization Group, Boeing Airplane Co. (Wichita).

Lessing, Henry C., B.S., Aero. Engineer P-1, N.A.C.A. (Moffett Field).

Maass, William George, B.S., Sales Promotion Consultant, Moreland Amick & Black.

Marochino, Joseph L., B.S. Ae.E., Stress Analyst, McDonnell Aircraft Corp.

Matthews, C. Frederick, B.A.Sc., Stress Analyst, A. V. Roe Canada, Ltd. (Canada).

McCaul, John N., B.A.E., Graduate Student, Rensselaer Polytechnic Institute.

McClure, Warren F., B.S., Engineer, Weight Control Unit, Boeing Airplane Co. (Seattle).

McInnis, James Ray, B.S. in Ae.E., Jr. Stress Analyst, The Glenn L. Martin Co.

Mellis, Richard M., B.S., Designer, Boeing Airplane Co. (Seattle).

Nilsson, Carl A., B.S. Ae.E., Jr. Design Engineer, Boeing Airplane Co. (Seattle).

Olive, Richard Dale, B.S. in Ae.E., Jr. Design Engineer, Goodyear Aircraft Corp.

Pahules, Paul M., B.S. in Ae.E.

Pasteur, Thomas B., Jr., B.Ae.E., Aero. Research Engineer P-1 (Temporary), N.A.C.A. (Langley Field).

Pflueger, Donald Edward, B.S. in Ae.E. & Ind.E., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Rabinowitz, Leonard, B. of Ae.E., Engineer, Flight Propulsion Research Lab., N.A.C.A., (Cleveland).

Reed, Wilmer H., III, B.S. in Ae.E., Aero. Engineer P-1, Aerodynamics Section, Flight Research Div., N.A.C.A. (Langley Field).

Ridler, Donald Alan, B.A.Sc. in Ae.E., Aero. Engineer, Flight Research Section, National Research Council (Canada).

Robertson, Floyd Lee, B.S. in Ae.E., 1st Lt., U.S.A.F.; Asst. Project Officer, A.M.C. (Wright Field).

Robertson, James Livingston, B.S. Ae.E., Sr. Aerodynamicist, The Glenn L. Martin Co.

Ross, Arthur Leonard, B.Ae.E., Engineer, Wing Design Group, Airplane Div., Curtiss-Wright Corp.

Schindler, Martin Harold, B.A.E., Aero. Research Engineer, N.A.C.A. (Langley Field).

Schneider, John J., B. of Ae.E., Jr. Engineer, Curtiss-Wright Corp. (Columbus).

Sentance, Alan P., B.S. in Ae.E., Engineer-Stress Analysis Technical Staff, A. V. Roe Canada, Ltd. (Canada).

Shard, Ralph F., Sr. Draftsman, Goodyear Aircraft Corp.

Shuford, Charles Britten, B.S. Ae.E., Research Engineer, Consolidated Vultee Aircraft Corp.

Shuford, Charles L., Jr., M.E. (Aero.), Aero. Research Engineer, N.A.C.A. (Langley Field).

Spencer, Jess B., Jr., Student, Cal-Aero Technical Institute.

Stein, Albert, B.S. in Ae.E., Stress Analyst, Test Section, Douglas Aircraft Co., Inc. (Long Beach).

Strand, Torstein, M.S. in Ae.E., Aerodynamicist "B," Northrop Aircraft, Inc.

Thomas, Gerald B., B.S., Student, Graduate School, Georgia Institute of Technology.

Thompson, William Clyde, B.S., Aero. Research Scientist, N.A.C.A. (Langley Field).

Vaughn, Harold R., B.S. Ae.E., Graduate Student, University of Colorado.

Whitaker, Carl Barnes, B.A.E., Stress Analyst, North American Aviation, Inc.

Wilhoit, Robert, B.Ae.E., Parts Controller, Northwest Airlines, Inc.

Yntema, Robert Theodore, M.A.E., Aero. Research Scientist P-2, N.A.C.A. (Langley Field).

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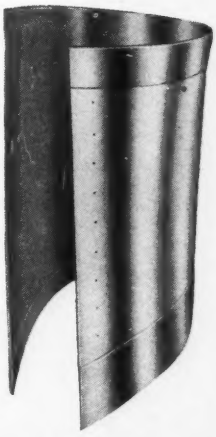

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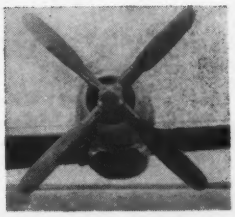

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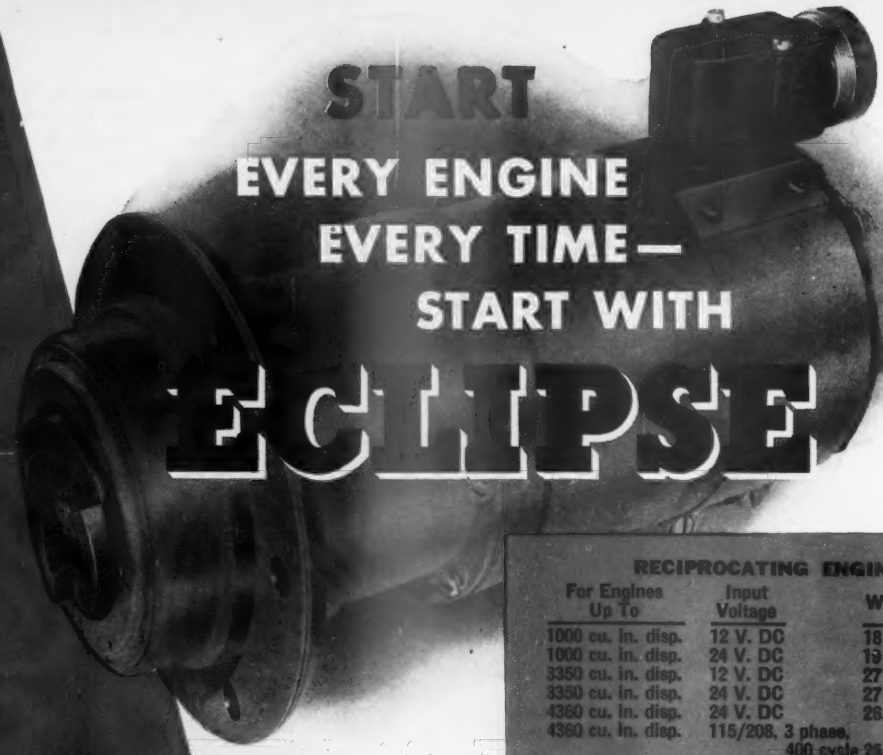

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4360 cu. in. disp.	24 V. DC	28.75 lbs.	1550*
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ADMA

Personnel Opportunities

This Section is for the use of individual members of the Institute seeking new connections and organizations offering employment to aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

WANTED

Helicopter Engineer—Experience in helicopter aerodynamics and stress analysis required. Apply in writing with a résumé of experience and education to American Helicopter Company, 900 N. La Brea Ave., Inglewood, Calif.

Aircraft Engineers—Opportunities for research and development on the B-36, world's largest bomber, and other heavy aircraft, at Convair's Fort Worth Tex., Division. Experienced engineers needed now in these classifications: Aerodynamicists, Engineering Designers, and Engineering Draftsmen. Send complete summary of training and experience to Engineering Personnel Office, Consolidated Vultee Aircraft Corporation, Fort Worth, Tex.

Structural Designers—Engineers experienced in design of sheet-metal structures desired for large cargo aircraft project. Graduate engineers preferred. All replies held confidential. Write, Project Engineer, Chase Aircraft Company, Inc., West Trenton, N. J.

Layout Draftsmen—Six or more years' experience in aircraft layout and design. Cargo aircraft experience desired. Graduate engineers preferred. All replies held confidential. Write, Project Engineer, Chase Aircraft Company, Inc., West Trenton, N. J

Stress Analysts—Personnel with experience on sheet-metal, monocoque, cargo-type aircraft desired. Graduate engineers with 5 or more years' experience preferred. All replies held confidential. Write, Project Engineer, Chase Aircraft Company, Inc., West Trenton, N. J.

Research Aeronautical Engineer—Engineering graduate with good command of physics and mathematics, to assist in the conduct of ballistic research. Excellent opportunity to obtain research experience and advanced degree. Address reply to D. W. Dutton, Director, Daniel Guggenheim School of Aeronautics, Georgia Institute of Technology, Atlanta, Ga., giving full particulars. Salary open.

Engineers—Rotary Wing—Now engaged in C.A.A. certification. Unlimited opportunities for qualified stress analyst, flight-test engineer, detail and layout draftsmen. Opening as Chief Engineer to take charge of certification work. Write full particulars to Jensen Helicopter Company, Inc., Tonasket, Wash.

Aeronautical Engineer—A position is available in the Research and Development Group of the Naval Bureau of Aeronautics in Washington, D.C., for an Aeronautical Engineer preferably with a background in electronics. Duties will involve research and development program planning and related tasks of justification presentation and analysis. Ability to express complex thought in clear readable fashion essential. This position is under Civil Service and will command a salary of $6,235 per annum. Address: Personnel Division, Bureau of Aeronautics, Department of the Navy, Washington, D.C.

Aeronautical Engineers—The U.S. Naval Air Station, Quonset Point, R.I., has announced a probational examination for Aeronautical Engineer (Power Plants) $4,479 a year, and Aeronautical Engineer (General) $4,479 to $7,432 a year. This examination will be used to fill future vacancies occurring at the Air Station and at other Federal Agencies throughout the New England states. Applications are being accepted until further notice. Write to Recorder, Board of U.S. Civil Service Examiners, U.S. Naval Air Station, Quonset Point, R.I., for further details.

Flutter Engineer—Aeronautical Engineering graduate with several years of experience in flutter and vibration problems for work on advanced military aircraft. Address reply to Engineering Personnel Office, North American Aviation, Inc., Municipal Airport, Los Angeles, Calif.

Preliminary Design Engineer—The Agricultural and Mechanical College of Texas, Department of Aeronautical Engineering, has an opening for a man to teach preliminary design and participate in aeronautical research. Facilities include large wind tunnel, excellent paved airport, and flight-research equipment. Rank and salary dependent on training and experience of applicant. Edward E. Brush, Department of Aeronautical Engineering, A. & M. College of Texas, College Station, Tex.

Jet Engine Specialists, Aerodynamicists, and Thermodynamicists—Needed for research and development work on supersonic ram-jet engine projects. Experienced men needed also for development work on electrical, mechanical, and pneumatic control systems—accessory and fuel. Good openings available at present because of large-scale expansion program. Write to, or apply at, Marquardt Aircraft Company, 4221 S. Lincoln Blvd., Venice, Calif.

Engineers and Scientists—The Navy Department is seeking engineers and scientists in practically every field for employment in Washington, D.C. Specific vacancies exist for aeronautical, civil, electrical, electronics, industrial, marine, and mechanical engineers, and for mathematicians, Naval architects, physicists, and others, with salaries ranging from $2,974.80 to $10,330. Some of the positions involve occasional travel to Naval Shore Establishments for the purpose of observing or participating in scientific tests of Naval equipment. Others require original research or planning scientific programs. All of the positions are concerned with the most recent advancements in the scientific field. Applications for the positions should be made on Standard Form 57, available at any first- or second-class Post Office, and should be mailed to Code 612, Room 1213, Main Navy Bldg., 17th and Constitution Ave., Washington, D.C.

Electrical and Aeronautical Engineers—Corporation engaged in development of aircraft remote control and telemetering equipment has need for engineers of several categories: (1) Young graduate electrical engineers having good background in electronics and communications. (2) Graduate electrical engineers with experience in electronics and communications. (3) Graduate electrical or mechanical engineers having background in servomechanism design. (4) Aeronautical engineers having experience in stability and control. Wing Engineering Corporation, Colonial Bldg., Philadelphia 7, Pa.

Research Personnel—Employment opportunities are for engineering graduates interested in subsonic or supersonic aerodynamic testing and research. Employees desiring to undertake graduate study can arrange their working hours accordingly. Write to Department of Aeronautical Engineering, University of Washington, Seattle 5, Wash.

Instructors—One opening for an aeronautical engineering graduate with industrial experience appropriate for teaching stress analysis and aircraft structures. Other openings are available for engineering graduates who will teach engineering drawing and engineering mechanics. Part-time employment permitting intensive graduate study can be substituted if applicant wishes to obtain an advanced degree. Write to Department of Aeronautical Engineering, University of Washington, Seattle 5, Wash.

Aerodynamicists and Aeronautical Engineers—Positions available for highly qualified technical personnel with good theoretical or experimental background to engage in development of facilities and model test work in stability, control, high-speed, and supersonic aerodynamics. Projects include new models of piloted and pilotless aircraft, new wind tunnels and associated equipment, and advanced testing techniques. Salary in accordance with qualifications and Civil Service regulations. In reply, please give summary of personal qualifications, education, and experience. Address—Director, David Taylor Model Basin, Washington 7, D.C.

907. Engineering Administrator—For instrument development laboratory in New York Metropolitan area. Experience on design, development, and manufacture of aircraft instruments, telemetering equipment, and servomechanisms desirable. Own engineering talent less important than ability to organize and direct others. Salary: $6,000 to $10,000.

895. Research Scientists—Experienced research scientists with advanced degrees and experience in applied physics, aerodynamics, thermodynamics, mathematics, or chemistry to perform supervisory research and act as permanent consulting group to engineering laboratory. Excellent opportunity for men with right qualifications. Salary, $8,000–$14,000 bracket.

893. Engineers—West Coast airplane manufacturer has need for additional aerodynamicists, stress analysts, and airplane control system designers having experience with servomechanisms and automatic pilots.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

AVAILABLE

916. Aeronautical Engineering Specialist—Age 26. Graduate engineer, mechanical major. Four years' experience government service as draftsman, design engineer in engineering, preliminary design, and design research divisions, Bureau of Aeronautics. Familiar with general design procedure. Knowledge of aviation, scientific, and naval affairs. Desires position as junior engineer, Washington representative (technical aide-engineering) for consulting engineers, research organizations, or Government contractors.

914. Flight Test Engineer—B.Ae.E. Age 32; married. Four years' experience in flight-test planning and analysis with high-performance military aircraft manufacturer. Responsible for several extensive research projects. Thoroughly familiar with the reduction of data obtained from complex automatic recording instruments.

913—Engineer—B.M.E. Graduate studies in mathematics and engineering. One year as assistant project engineer on automatic aircraft

control. Two years in analysis of the dynamics of missiles and their control systems. One year in charge of design and operation of equipment employing electronic analogue computers for simulated flight test of actual missile control apparatus. One year in charge of analytic evaluation of missile guidance systems.

911. Management, Administration, or Sales—B.S. in M.E. Over 20 years' experience in aviation, including engineering, production, quality control, contracts, contract termination, materials, costs, and sales. Five years' research, N.A.C.A., hydrodynamics and aerodynamics. One year flight performance analysis. A and E mechanic; private pilot. Supervisory and administrative experience. Presently responsible for test and development of jet power plants at missile test center. Desires responsible position with young organization needing a versatile, well-informed executive. Prefers West Coast.

910. Aeronautical Engineer and Aviation Executive—Young, aggressive, responsible, full of initiative, with 15 years' experience, including 12 years aviation, 3 years nonaviation. Detailed aviation experience includes 9 years' aeronautical ngineering in stress analysis, airplane structural design, testing, aerodynamics, supervision, and 3 years as top manager of aviation division (engineering and sales) of a large corporation. Also has acted as a consultant to U.S. Army Air Forces. Has actively participated in a responsible or key engineering position during the certification of eleven completed airplane projects (Army and civilian), and approximately 25 of a preliminary or partial nature. Thoroughly familiar with late Civil Aeronautics Administration Regulations in work as Assistant Chief of the Airframe and Equipment Engineering Division; B.S.M.E., University of Kansas, 1932; *Who's Who in Engineering;* and *Who's Who in Aviation.* Desires interview with responsible companies seeking top-drawer engineering talent and know-how to take charge of engineering and/or management of aviation division or equivalent.

909. Physicist-Aerodynamicist-Thermodynamicist—Ten years of diverse experience in the aircraft and gas-turbine fields. Has done internationally recognized research. Desires new position, preferably on consulting basis.

908. Power-Plant and Engine Accessory Designer—Graduate M.E., German university. Extensive design and testing experience. Fully conversant with engine layout and all phases of development. Considerable design and research background on fuel injection systems.

906. Management or Engineering—B.S. in A.E. Ten years' experience including teaching, aircraft stress analysis, and aircraft propellers. Six of these years as Assistant Chief Engineer and Chief Engineer in propellers. Will accept position in other fields as well as aircraft.

904. Aeronautical Engineer—M.S. in Ae.E. Five years' experience in field of aeroelasticity.

903. Public Relations Representative—Seven years' experience in the active promotion of aircraft and propellers by teaching; lecturing societies, industrial, and civic groups; preparing publicity programs and press releases and over 40 technical and trade articles and papers. Writer—Editor of 1947 First Award Winning Paper of Lincoln Arc Welding Foundation contest. Foreign experience (Europe) representing U.S. aircraft manufacturer. Member U.S. T.I.I.C. team which explored German industry and returned latest developments to this country. Experienced in conducting plant tours, trade displays, civic, educational, press relations, and advertising agency liaison. Has had charge of entire program to introduce a unique mechanical product, educate the sales organization, and inform the trade and public. Desires position with manufacturer making finished mechanical products who requires the aggressive practice of public relations in the modern concept. Gas-turbine field of especial interest. Two years of college, 1 year of technical school. Age 29; married.

901. Aeronautical or Mechanical Engineer.—B.S. degree in Aeronautical Engineering. Graduate student for 1½ years in Aeronautics and Applied Mechanics. Two years' experience in the aircraft industry as a senior draftsman and aerodynamicist and other related engineering work. Will accept position anywhere in the U.S. or abroad.

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891. Professor—Professor of Aeronautical Engineering desires change to position in more favorable climate. Industrial experience as chief aerodynamicist. Papers on dynamics and thermodynamics. Advanced degree.

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Books

(*Continued from page 84*)

PRODUCTION

Elementary and Applied Welding. Herbert P. Rigsby and Chris Harold Groneman. Milwaukee, Bruce Publishing Co., 1948. 151 pp., illus., diagrs.

Designed for the beginning student, the first third of this book is devoted to equipment, materials, and methods in oxyacetylene and arc welding. The final two-thirds is devoted to class projects.

SCIENCES, GENERAL

MATHEMATICS

Spherical Harmonics; an Elementary Treatise on Harmonic Functions with Application. T. M. MacRobert. 2nd Rev. Ed. New York, Dover Publications, Inc., 1948. 372 pp. $4.50.

In this edition of a book first published in Scotland in 1927, new chapters have been added on some additional properties of the hypergeometric function and on the associated Legendre functions of general real degree and order. A set of 88 miscellaneous examples has also been added. The purpose of the author is to provide a textbook on the elements of the theory of the spherical harmonics, with applications in the field of mathematical physics.

Technical Descriptive Geometry. B. Leighton Wellman. New York, McGraw-Hill Book Co., Inc., 1948. 508 pp., diagrs. $4.00.

The author's purpose is to provide a complete up-to-date treatment of descriptive geometry for the student and the industrial draftsman. Presentation is based on the point of view that reasoning should precede visualization and that the student should proceed only on the basis of established facts. The auxiliary view method is used throughout, in accordance with industrial practice. The author is a professor at Worcester Polytechnic Institute.

STRESS ANALYSIS & STRUCTURES

Mechanics of Materials. Glenn Murphy. Chicago, Irwin-Farnham Publishing Co., 1948. 310 pp., illus., diagrs.

The author's purpose is to provide a textbook for the first course of the engineering student, in the mechanics of materials, with emphasis on the principles of statics, the characteristics of the geometry of the loaded member, and the effects of the properties of the material in the consideration of each type of stress situation. Emphasis is avoided on the formulas as such. Elementary aspects of design aspects are introduced as an aid to the evaluation of the analysis as related to practical engineering problems. There are 659 problems grouped at the ends of chapters.

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